# TRANSACTIONS AND PROCEEDINGS

OF THE

# ROYAL SOCIETY OF SOUTH AUSTRALIA

(INCORPORATED)

VOL. LX.

*[Each Author is responsible for the soundness of the opinions given and for the accuracy of the statements made in his paper.]*

PRICE: TWENTY SHILLINGS.

**Adelaide:**
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(INCORPORATED)

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*BY DR. C. T. MADIGAN*

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# Transactions
of
# The Royal Society of South Australia (Incorporated)

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## ROYAL SOCIETY OF SOUTH AUSTRALIA CENTENARY ADDRESS

by The President (Dr. C. T. Madigan).

Presented at the Ordinary Meeting on May 14, 1936.

## THE PAST, PRESENT, AND FUTURE OF THE SOCIETY, AND ITS RELATION TO THE WELFARE AND PROGRESS OF THE STATE.

*Introduction.*—The Council of the Royal Society was desirous of taking some part in the Centenary celebrations of the State of South Australia, but considered that, owing to the nature of the Society, its contribution could not be otherwise than internal, so that it was decided that the Centenary should be marked by an address by the President in the nature of a review of the progress of the Society and its relation to the progress of the State. This address is to be followed during the year by addresses by other Fellows of the Society dealing in some detail with the work of the more important sections of the Society's sphere of activities.

The time is very opportune for a stocktaking of the Society's position, and a reconsideration of its policy, objects, and future. The Royal Society is really older than the State itself, for though it has had an unbroken existence only since 1853, apart from a mere change of name, yet its origin can be traced back to the South Australian Literary and Scientific Association, initiated among the founders of the Colony in London in 1834. Thus we can feel that we are not only celebrating the Centenary of the State, but if not actually of the Society itself, at least of the first scientific organisation in the Colony, of which we are the direct descendant.

The Presidential address was initiated by Professor Tate in 1878, when he stated that he hoped he had established a precedent. At that time Professor Tate was able to give a bibliography of the whole of the scientific work dealing specifically with the new Colony that had so far been published. Such a task would be practically impossible today. The giving of a Presidential address never became an annual custom, and Tate's precedent has rarely been followed. In the 57 years since the first Presidential address, 18 such addresses have been given, but no further attempts to prepare a bibliography of scientific work have been made. This year we propose to give a review rather than a bibliography. Of the 18 addresses, 9 have been papers of a purely technical nature read by the President, and of the remaining 9, while they were of a more general character, yet only in a few cases did they review the work of the Society or refer to its policy. Tate himself followed his first address by a technical paper, but in 1880 gave a record of current literature relating to the natural history of Australia, and particularly of South Australia.

In 1895 his title was "Some Work of the Society since 1876." This was his last Presidential address, and in it, after making brief reference to past achievements in geology, anthropology, and comparative anatomy, he proceeded in greater detail under the sub-heading of "Some Recent Advances to Our Knowledge of Natural History of Australia."

In 1889 Professor Rennie discussed the present state of South Australian industries in which chemical science is involved; in 1901, agriculture in its relation to biology and chemistry; and in 1903, the fisheries of Australia. In the 1901 address he urged the need of further work in entomology, plant pathology, diseases in wine, the relation of birds to insect life, rural engineering, and diseases in stock. Canon Blackburn gave an address on the ultimate aims of natural science, in 1891. Sir Joseph Verco, in 1906, gave a review of the work of the Society from 1903 to 1906, published in vol. xxx of the Transactions. This was one of the most useful and inspiring Presidential addresses ever presented to the Society. Not only was past work reviewed, but attention was called to the branches of natural science which had hitherto been neglected. The policy of the Society, particularly in respect to the library, was also touched upon.

Dr. R. S. Rogers, in vol. xlvi, 1922, gave "A History of the Society, particularly in its Relation to other Institutions in the State." The evolution of the Society, from its beginnings in London, is here carefully traced, with biographical notes on the outstanding personalities in the foundation and subsequent vicissitudes of the various bodies whose successively discarded mantle finally fell upon the Royal Society. This address will long remain the standard work for reference on the foundation of the Society and the chronology of the important events in its history and constitution. The last Presidential address was given in the following year, thirteen years ago, by Dr. Pulleine, on "The Pigmy Races of the World."

## The Past.

*Historical Review.*—The past history of the Society divides itself naturally into three parts, all completely distinct, the period prior to the founding of the Adelaide Philosophical Society in 1853, the Adelaide Philosophical Society from 1853 to 1876, and the Adelaide Philosophical Society, and then the Royal Society from 1877 to the present. The first period is fully dealt with in the address by Dr. Rogers already referred to. I will merely repeat the salient features.

The South Australian Literary and Scientific Association, formed in London in 1834, collected together a small library and sent it out to the Colony. In the first busy years of landing the Society found no leisure for its anticipated activities at all, and does not appear ever to have functioned in the Colony, but its founders took an active part in subsequent societies, and its little library passed on through two more such societies and was their focal point and the only lasting thing in them.

In 1838 the Adelaide Mechanics' Institution was formed, to which the Literary and Scientific Association handed over its books. This institution had a reading room and circulating library, and evening lectures were delivered. After six years, in 1844, the South Australian Subscription Library rose out of the ashes of the Mechanics' Institution, and took over its books. In 1847 a rival body, The Mechanics' Institute, sprang up, but in the following year the two combined as the South Australian Library and Mechanics' Institute.

The first period of the history of the evolution of the Royal Society closes a few years after the formation of this Institute, with the foundation in 1853 of the Adelaide Philosophical Society, mainly through the initiative of John Howard Clark, who for many years remained the backbone of the Society. This was the

first scientific society founded on a firm and lasting basis, for it has survived to the present day, with only one important revival and a later change of name.

The second period is the history of the 23 years of the Adelaide Philosophical Society, from its beginning to the time of this revival in 1876.

Through the combined efforts of the Adelaide Philosophical Society and the South Australian Library and Mechanics' Institute, the South Australian Institute was brought into being in 1856. This was to be maintained by the Government, and on the passing of the Institute Act of 1857 the old S.A. Library and Mechanics' Institute went out of existence. J. H. Clark and B. H. Babbage were the moving spirits in this important advance.

In 1859 the Adelaide Philosophical Society became incorporated with the S.A. Institute, receiving housing in return for a rental. This association continued for 25 years, until the Public Library, Museum, and Art Gallery were brought under one board of management in 1884, replacing the Institute, and the Philosophical Society became affiliated with the new body. This incorporation with the Institute linked the new Philosophical Society with the chain of past events.

The Philosophical Society continued a useful existence, at times handicapped by lack of papers, lack of interest, and lack of funds, and finally getting into rather low water about 1872, until the coming of the University and Professor Tate in 1876, when its whole status was changed, new rules were drawn up, and the Society entered upon the third period of its development, which extends to the present day. For the first time, in 1878, publication was systematically dealt with and the volume of the Transactions has appeared annually ever since. In 1879 the Society was put on the same footing as the Institutes, which by this time had spread through the country, in the matter of Government grants, the Society receiving a pound for pound subsidy on the amount of the annual subscriptions.

In 1880 the Society obtained permission from Her Majesty Queen Victoria to assume the title Royal, and the name was changed from the Adelaide Philosophical Society to the Royal Society of South Australia. Her Majesty also accepted the position of Patron of the Society. Up to that time the State Governors had always consented to be Presidents of the Society, and very frequently took the chair at the ordinary monthly meetings. Sir E. E. F. Young, Sir R. G. MacDonnell, Sir Dominic Daly, Sir James Ferguson, and Sir Anthony Musgrave all figure prominently in the minute books of the Philosophical Society. With the new rules in 1878, Governor Sir William Jervois became Patron and Professor Tate President. Two years later, with the change of rules on the assumption of the title Royal Society, when the Queen became Patron, the Governors ceased to have any active connection with the Society, until the death of Queen Victoria, since when the King's representative in South Australia has always accepted the position of Patron, and the President has been elected from among the Fellows of the Society.

In 1903 the Royal Society was incorporated, for the better management of the newly established endowment fund. Since the beginning of the third period in 1877 to the present the Society has steadily advanced in financial stability and in status in the world of Science.

*Objects of the Society.*—The period prior to the foundation of the Philosophical Society in 1853 is now of little more than historic interest. The institutes and societies in that period functioned much as a country institute and literary society does today. Their object was discussion and dissemination of knowledge, not original work, and thus they have left no permanent records of their activities behind them. The original idea is summed up in the objects of the S.A. Literary and Scientific Association, drawn up in London in 1834, which were "The Cultiva-

tion and Diffusion of Useful Knowledge throughout the Colony." With these final remarks we will dismiss the pre-Philosophical Society period and deal only in the remainder of this address with the Adelaide Philosophical Society and the Royal Society, which I will refer to indifferently as the Society.

The laws, as they were called, of the Society, on its foundation in 1853, state that the objects are "the discussion of all subjects connected with Science, Literature, or Art." This would seem to indicate the exclusion of any original work, but that was by no means the intention, for in the first annual report in January, 1854, the objects are more clearly put forth in these words: "The originators of the Society had a two-fold object in establishing it. They were desirous that it should not only afford an agreeable medium of intercommunication to those whose tasks lead them to the pursuit of similar studies, but that it should also present a means of illustrating and recording the many interesting natural phenomena which are altogether peculiar to this colony, and which it is to be feared would be otherwise in a very few years' time irrecoverably lost to the records of Science." Thus it is clear that at the outset one of the main objects was the recording of the natural history of the State. However, the old literary society traditions were still strong, and it is curious that in the first 24 years of the Society's history, in spite of the clear intentions of the founders, the only natural history recorded was by the Rev. Tenison Woods on the Tertiary fossils. The objects remained unchanged in the rules for this period of 24 years, but natural science was greatly neglected. The actual nature of the proceedings at that time will be mentioned later.

The rules were revised in 1878 under Professor Tate, and the objects were then defined as "the diffusion and advancement of the arts and sciences by the meeting together of the members for the reading and discussion of papers connected with the above subjects, and by other approved means." The "arts" were still included, but it is not clear just what was meant to be covered by that term.

In his first Presidential address, in the year of the new rules, 1878, Tate enlarges upon the objects, and says there are still, as at the foundation, two fundamental objects, that the Society should form an agreeable medium of intercommunication, but that it should also present a means of illustrating and recording the many interesting natural phenomena which are altogether peculiar to this country. From this time onwards the major interests of the Society have undoubtedly been in this direction of natural history. At the change of name to Royal Society in 1880 the "objects" clause in the rules remained unchanged.

In 1880 Tate seemed a little apprehensive that the Society was becoming so technical that it was losing popular support, and he advocated that it might acquire popularity without in any particular impeding the attainment of the higher objects of the Society, by delivering popular expositions of recent advances or of new discoveries in science. This was the last appearance of the ghost of the old traditions. No steps were taken in the direction indicated, but the position was met to some extent by the formation of the more popular sections of the Society a few years later.

In 1889 Professor Rennie remarked in his Presidential address that the subjects dealt with by Fellows were for the most part connected with Natural History, almost an apology for the chemical nature of his address.

In his last Presidential address, in 1895, Professor Tate stated that "facts of identification and distribution are fundamental, and to the accumulation of these the Society has almost exclusively given its attention during the last 15 years or more." He remarks that originally the Fellows were of the "good all-round type," and, therefore, popular expositors, but by then specialization was already far advanced. That it took the form principally of specialization in natural history was due to the energy and enthusiasm of Tate himself.

The next reference to the policy and objects of the Society was by Dr. W. L. Cleland in 1898. He said: "The object of the Society . . . is to place on record only new facts relating to science as they bear on South Australia." This seems a narrower view, that does not appear to have been generally held, nor is held today, though the trend of activities actually has been more and more in that direction. He goes on to say that "To some of the Fellows it may be a matter of regret that attempts have not been made by the Council to place scientific subjects in a popular form before the meetings. It should be remembered, however, that the functions of a Royal Society are not to popularize science nor to give instruction, but simply to publish results of work done or to discuss the deductions which may legitimately be drawn from ascertained scientific data." This indicates that the old idea of exposition was quite defunct. Even opportunities for profitable discussion, he points out, did not often present themselves, owing to specialization and the few workers in each subject. That is even more the case today. At that time the University and other bodies were already having a marked effect in depriving the Society of one of its primary objects, to provide a common meeting ground for the exchange of scientific thought. The popularizing of science also was in more efficient hands in the University, and in the Society's sections, so the Society could feel free from any obligations in that direction, and its future utility would be measured by the quality of its published memoirs.

The rules were revised in 1902, under Professor Rennie's Presidency, and the "objects" clause then read: "The objects of the Society are the promotion and diffusion of science by meetings for the reading and discussion of papers and other methods." The only change was the dropping of the word "arts," which never seems to have had any bearing on the Society's activities.

In 1906 Sir Joseph Verco mentioned that medical science was not represented among the subjects which engage the Society's attention. In his review of the work of the Society he said: "This record . . . indicates assiduous and intelligent endeavour along truly scientific lines, and along many lines. And this variety of subjects dealt with is one of the most satisfactory features. . . . Only by such diversity can this Society be made generally interesting or generally useful, and deserve its name."

The next revision of rules was in 1923, when "objects" was changed merely by the substitution of the words scientific knowledge for science. The last revision, which gave us the rules of today, was made in 1931, and the clause now reads: "The objects of the Society are the promotion and diffusion of scientific knowledge by meetings for the reading and discussion of papers, and by such other methods as the Council may from time to time determine." It can thus be seen that the objects of the Society have never really undergone any radical change, and that specialization in natural history has not only been a natural development in a new country, but also has always been a fundamental policy.

*Past Achievements.*—The fore-runners of the Society, in the first seventeen years of the State's history were, as I have shown, of the Institute type, and though they did good in their way, they had little connection with Science and they left no permanent records. The achievements of the Society itself divide themselves very definitely into two groups, those of the pre-Tate and those of the post-Tate periods. The former covers most of the history of the Philosophical Society, for the name was changed only four years after Tate's arrival. In this first 23 years of the Society's existence the attendance at meetings was small, often only half-a-dozen members, the publicity for papers was limited, and there were no funds for publication. Very little original work was presented before the Society. An annual report was usually printed, which contained an abstract of the papers read, and in a few cases the papers were printed in full. These

reports were apparently intended for private circulation only. They were printed for the years 1854-1858 and 1865-1872, after which there was no printing till Volume I of the Transactions appeared in 1878. These reports may be found bound together in the Adelaide Public Library under the title Adelaide Philosophical Society Reports, 1853-1871. Though containing much of historical interest, they preserve practically nothing of permanent value except the Rev. T. Woods' descriptions of new types of South Australian Tertiary fossils, referred to above and begun in 1865. The character of the proceedings may be gauged from the list of papers read in 1858, which were on "Mesmerism," "The Goodness of the Deity as Manifested in the Creation of the Animal Kingdom," "The Relations of Capital to Labour," "National Education," "The Fertility of Soils," "Drying Fruits," "The Probabilities of Gold in South Australia," and "The Proposed Expedition into the Interior." In the eighteenth and last report of the Adelaide Philosophical Society, printed in 1873, and covering the two years 1871 and 1872, the papers mentioned for the two years are "Elementary Education," "The Flight of Birds considered with reference to Aerial Navigation," "The Government Bill for promoting Elementary Education in South Australia," "The Fermentation of Grape Juice," and "The Theory of Evolution."

Though the attendance at meetings was small in those days, it consisted of very influential people. The Governor was frequently in the chair, and the Bishop, the Chief Justice, the Judges, the Surveyor-General, the Postmaster-General, the leading educationists and the newspaper editors were active members; in fact, it may be said that the Society included the majority of the prominent intellectuals of the young colony. Thus, though its scientific status was originally negligible, its local popular status was very high. It was the only body in the country which could speak with any authority on matters of education or applied science, for both of which there was great need. With the prestige of the Governor and the strong support of the Press (Mr. W. W. R. Whitridge, editor of the *Register*, was for many years a member), its influence, both as a Society and as individuals, was very considerable. Its printed papers are now of no importance, but its deeds, whose authorship is now lost sight of, will live for ever. The Society today is in exactly the reverse position.

The old Society was the fore-runner, and in many respects may be considered to have been the founder, of all the scientific institutions which have arisen since, for its discussions, its resolutions, or its memorials to the Government may be found in connection with the foundation of almost all of them. Its daughters have now grown up, and they have become the authorities in the various branches of science which they represent. Specialization has inevitably led to decentralization, and that essential requirement of scientific work, publication, has become the chief function of the Royal Society.

I will give a few examples of this early work of the Society. I have already mentioned the foundation of the Institute, out of which eventually evolved the Public Library, Museum, and Art Gallery. The Society memorialized the Government on this subject of the Institute in 1856, and the Institute Act was passed in 1857. In 1856 the Society advocated the exploration of the North-West Interior, and memorialized the Government on that subject as well. The work was eventually carried out on the lines suggested by Mr. B. H. Babbage, the President. The drainage of the City was also discussed in that year.

One of the first objectives of the Society had been the building up of a Natural History Museum, but for twenty years, owing to lack of funds and space, the museum remained a small mineralogical collection in a narrow room upstairs in the Institute Building. It had been hoped that on the building of the Institute and the incorporation in it of the Society, proper space would be found for a

museum. One of the objects of the Institute was, at the instigation of the Society, the establishment of a Natural History Museum, but funds for this were not forthcoming. Most of the expenditure was in the country. However, in due course a separate building was provided and a Museum Director appointed. We undoubtedly owe the Museum to the early efforts of the Society.

There were many papers and discussions on the City Drainage in 1865 and 1866, culminating in a memorial to the City Council on Drainage and Sewers in 1867. As a result a Bill was introduced into the House to enable the Corporation to begin the work of deep drainage, thus initiating the modern system. Railway construction and gauges also occupied the attention of the Society at that time.

In 1868 the Society turned its attention to education, and many papers on the subject were read, ending in a resolution "that this meeting is of opinion that the Government should take some action so as to provide means for the compulsory education of the children of those classes that are either unable or unwilling to pay the usual school fees."

In 1869 the Society passed a resolution "that this meeting strongly impresses on the Government the necessity of immediately erecting a time-ball at the Semaphore on the plan of the model produced by Mr. Todd for the use of the shipping at Port Adelaide." The time-ball has just been dismantled in this year of grace 1936. Wireless time signals had rendered it obsolete.

Participation in public affairs did not cease with the reorganisation of the Society in 1877. It is rather that the purely scientific side, hitherto neglected, became much more strongly developed. New Government departments, too, were able to relieve the Society of some of the burden of responsibility which it felt to be upon it. While on the subject of the Society's part in the development of the State, I will briefly refer to the more important actions taken in the later period. Under the Presidency of Professor Tate, the necessity of a geological survey of the Colony was urged upon the Government in 1877; the teaching of practical mining engineering at the University was advocated in 1879, which was probably the first step towards the establishment of the School of Mines, for Professor Tate was a member of the first council of that institution in 1888; reports on artesian water were supplied to the Government in 1881, when there was no Government Geologist to advise on these subjects. In 1890 the Society urged the Royal Society of New South Wales to approach its Government to appoint a geologist for Broken Hill. Professor Tate fired his final shot in 1895, when he said in his last Presidential address: "South Australia accepts a degrading position in relation to its agriculture and botany with Victoria and to its geology with New South Wales."

Professor Rennie, in his Presidential address of 1889, gave much advice of direct value to citizens. For the agriculturalist he discussed the exhaustion of soils and the use of artificial manures, and advocated the institution of experiments on the best methods of farming. In the same address he made helpful suggestions on sulphuric acid manufacture, gold recovery, salt works, and gas retorts.

In 1901 the title of Professor Rennie's Presidential address was: "Agriculture in its Relation to Biology and Chemistry." In this address he particularly advocated the promulgation of knowledge of the necessity of nitrogen in soils and of the methods of its production, and pointed out the value of fallowing. The use of phosphates is also discussed. He urged the need of more research work in agriculture, of something more than Roseworthy, and said: "I am pleading for scientific investigation, which will inevitably yield almost immediately results of great practical value, and the sooner its importance is recognised the better will it be for South Australia." Today we have the Waite Institute, which was rather long in following such a strong appeal.

In the same address attention is called to the necessity of the control of fisheries, and in 1903 Professor Rennie gave an address on the "Fisheries of Australia." The Society took an active part in supporting measures then before Parliament for fish protection, but control is still inadequate, and much scientific investigation into the life history of our fish, as advocated by Professor Rennie 33 years ago, is still essential before legislation can cope with the problem of the gradual disappearance of our best edible fish.

In 1898, during the Presidency of Dr. W. L. Cleland, a resolution was passed on the desirability of united action on the part of the Australian Colonies to arrange and publish an authoritative treatise, as complete as possible, on the Australian Race. No direct results appear to have followed this resolution, but at last, during recent years, the native races are receiving the attention and study they have long deserved, with Professor J. B. Cleland, Dr. Cleland's son, as chairman of the Board of Anthropological Research in the University of Adelaide.

One of the last direct actions of the Society was a joint deputation to the Government in 1906 from the Society and the South Australian Astronomical Society, under the leadership of Professor Howchin, to ask that a seismograph be installed in the Observatory, which project came to a satisfactory conclusion.

In addition, there is the important work of the Native Fauna and Flora Protection Committee during the past 48 years, which will be referred to under the Sections of the Royal Society.

*Publications.*—These deputations, resolutions, and addresses show that the Society in the past has taken no mean part in matters directly affecting the welfare and progress of the State. Now let us turn to the more purely scientific work of the Society, which has been not only of indirect value to the State, but has had the whole world for its field in the advancement of human knowledge.

Prior to 1877 the scientific work was of small account, and its only publicity was in the South Australian Press, in the form of reports of meetings. In 1876 there arrived the scientific leader the Society had long awaited, Professor Ralph Tate, whose energy, organising ability, and wide range of scientific interests were the inspiration of the Society for the next 25 years of his association with it, until his death in 1901. Original scientific contributions came in abundantly for the first time, and publishing was put on a sound and permanent basis by the appearance in 1878 of the first of the subsequent 59 annual volumes of the Transactions. Exchanges were soon arranged with other learned societies, and before long our Transactions had found their way into the libraries of every civilized country in the world.

I have classified the papers read before the Society for the two periods, 1853-1876, and 1877-1935. In the first period, the list represents papers read. Abstracts of most of them appeared in the daily paper, and in the annual reports when these were printed, and some were printed in full. The first list includes papers on anthropology 7, on astronomy 3, botany 9, chemistry 10, entomology 6, geology 17, mineralogy 0, palaeontology 5, mathematics 5, zoology (other than entomology) 16, physics 7, meteorology 3, experimental biology 0, medical subjects 5, engineering 25, literature 7, art 5, physiology and anatomy 5, philosophy 17, geography 11, agriculture 11, education 6, miscellaneous 26; a total of 206.

The second list includes all the papers published in the Transactions from Vol. I, 1878, to Vol. LIX, 1935, a total of exactly 1,100 papers. They are made up of anthropology 67, astronomy 6, botany 202, chemistry 28, entomology 249, geology 159, mineralogy 23, palaeontology 70, mathematics 3, zoology (excluding entomology) 233, physics 25, meteorology 13, experimental biology 5, medical subjects 8, miscellaneous 9.

Classification was much simpler for the second list, and only nine papers could not be placed under the headings chosen. Entomology was listed separately from the remaining zoological subjects, as it forms much the largest unit in zoology.

Physiography has been included under geology. It will be noted that literature, art, philosophy, physiology, geography, agriculture and engineering have entirely disappeared. The geographical papers in the first list were mainly descriptions of other lands, and the agricultural papers were on viticulture and such subjects. In the second series, the agricultural papers are of a much more scientific nature, mainly on the properties of soils, and they fall more naturally under the headings of chemistry or meteorology.

The papers may be more broadly classified into five groups, in order to show the chief directions the activities of the Society have taken. The exact or mathematical sciences form a group of their own, including astronomy, chemistry, physics, mathematics, meteorology, experimental biology, and medical subjects. Anthropology is a separate unit. The remainder are the natural or descriptive sciences and fall under the three headings, botany, zoology, and geology. For this purpose entomology is included in zoology, and mineralogy and palaeontology in geology. The lists then read:—

| | 1853-1876. | 1877-1935. |
|---|---|---|
| Anthropology | 7 | 67 |
| Botany | 9 | 202 |
| Zoology | 22 | 482 |
| Geology | 22 | 252 |
| Exact Sciences | 33 | 88 |
| Totals | 93 | 1,091 |
| Other Papers | 113 | 9 |
| Grand Totals | 206 | 1,100 |

The lists for the two periods made up under these headings show the great relative increase in work in the natural sciences, and the gain of the natural over the exact sciences.

*The Sections.*—In spite of his great enthusiasm for, and remarkable success in, promoting original work in the Society, Professor Tate did not lose sight of the need and value of a more popular side to the Society's activities. In fact, this was encouraged and fostered under his regime, but separated from the more technical side, by the formation of Sections in the Society, membership of which did not necessitate Fellowship of the Society nor the full subscriptions. The first formed and most important of these is the Field Naturalists' Section, inaugurated in 1883 by a meeting in the Town Hall, at which Professor Tate gave a lecture on the objects of the Section. One of the chief activities of this section has been field excursions of a popular nature. Since 1919 the Section has published a quarterly journal at its own expense, entitled *The S.A. Naturalist*. The Section holds an annual wildflower show which is always a popular attraction.

The Field Naturalists' Section formed, in 1888, a very important Sub-section styled the Fauna and Flora Protection Committee, which has had a very useful and active existence. It issued its fortieth annual report in 1928, but no reports have since appeared in the Transactions of the Royal Society. The Government grant ceased in 1930, since when the Royal Society has been unable to publish the annual report of the Field Naturalists' Section, including that of the Fauna and Flora Protection Committee. Now that the Government assistance

has been partially restored, it is to be hoped that future Transactions will continue to include a synopsis of the activities of these important sections.

Much excellent legislation for the protection of our animals and plants has been introduced at the instigation of this committee. Its most outstanding performances have been in connection with the National Park at Belair, and Flinders Chase on Kangaroo Island.

It was through the Committee's persistent efforts that the old Government farm at Belair was placed beyond the control of Parliament and vested in Trustees, at a time when it was already cut up into blocks for sale. That was in 1891. The President of the Royal Society has always been an ex officio Commissioner of the National Park.

The struggle for a national reserve on Kangaroo Island began two years after the Belair Park was secured. It included a public meeting under the auspices of the Society in 1906, and ended sixteen years later in the Fauna and Flora Reserve Act, 1919, proclaiming "Flinders Chase," an area of 198 square miles, for the protection, preservation, and propagation of fauna and flora. The Committee has always kept an eye on Game Acts, helping in their introduction and calling attention to their abuse.

A Microscopical Section was formed in 1887. It has had a chequered career. It was revived in 1903, but held its last meeting in 1913. Another revival took place in 1928, but under the title of the Microscopic Committee of the Field Naturalists' Section, which will ensure for it a more permanent status.

The Malacological Section has had a similar history. It was founded in 1895, resumed in 1901, and held its last meeting in 1917. Then the Field Naturalists took it under their wing as the Shell Collectors' Committee, since when it has continued to do useful work under a much more suitable name.

The Astronomical Section came into being in 1892, under the Presidency of Sir Charles Todd. After eight years it dissociated itself from the Society and has ever since led a separate existence as the South Australian Astronomical Society. Its books are housed in the Royal Society's premises, where it holds its meetings.

## The Present.

I have endeavoured to trace the history and policy of the Society from its beginnings to the present day. The present position as regards status and activities has been arrived at by a process of natural evolution, though the policy has remained practically unchanged throughout. The Society has never been more flourishing than it is today, in spite of the definite change in the nature of its status. This change can be concisely summed up as a change from a condition in which the Society's activities were largely discussional, when original work was practically negligible, but local popular status was high owing to the Society frequently speaking with one voice on questions of public interest and importance, to the present position, where specialized original work is the main objective, individualism has replaced concerted action, and publication has superseded exposition. Local popular prestige may have fallen, but this loss is far outweighed by the gain of an international reputation for the very considerable additions to human knowledge given to the world through the medium of the Transactions and Proceedings of the Royal Society of South Australia. At the present moment our Transactions are sought by 257 learned societies throughout the world.

The interest shown in our work, as well as the publicity available to the workers, is shown by the following list of the number of learned societies in each country which receive our Transactions:—Great Britain, 29; Canada, 7; South Africa, 5; New South Wales, 12; Victoria, 7; Queensland, 6; Western Australia, 4; Tasmania, 4; South Australia, 12; Canberra, 4; New Zealand, 5; Ceylon, 1;

Federated Malay States, 1; India, 4 (making a total of 101 within the Empire), United States, 50; Germany, 15; France, 7; Italy, 8; Spain, 2; Portugal, 1; Austria, 4; Hungary, 2; Czecho-Slovakia, 1; Belgium, 7; Holland, 2; Denmark, 4; Finland, 3; Norway, 4; Sweden, 4; Switzerland, 6; Poland, 2; Russia, 6; Esthonia, 1; Latvia, 1; China, 6; Japan, 8; Hawaii, 2; Argentine, 2; Brazil, 2; Uruguay, 2; Mexico, 3; Philippines, 1 (or a total of 156 foreign societies). All these societies send us their publications in return, so that the Royal Society has acquired a very valuable collection of scientific journals, in many cases the complete series of publications of the society concerned. The list of exchanges is continually being added to.

The Society no longer sees any necessity for attempting to popularize science. The schools, the University, and other scientific and technical institutions have relieved it of that duty. The Field Naturalists' Section, which is as strong as ever, encourages the study of natural history as a hobby, and fills the need of those who desire some skilled guidance in that direction.

As regards the present trend of the Society's interests, it has been shown that they are definitely in the direction of Natural History, not only because that has always been a fundamental objective, but also because of the growth of all the highly specialized societies, particularly in the applied sciences, with their own journals. The journals have become specialized, and it has fallen to the Royal Society to specialize in Natural History. I have only to mention the Commonwealth Council for Scientific and Industrial Research, the Australian Institute of Engineers, the Australian Chemical Institute, and the State Geological Surveys, to indicate the great range of scientific journals now available for the publication of specialized work. Science has now become so international that leading journals all over the world are also available to Australian workers for the publication of high-grade results of more than local interest.

The specialized institutions have naturally become the authorities in their various branches of science, so that few directions are left in which the Royal Society is naturally looked to for guidance. Leadership in investigation in subjects of national economic importance has naturally passed to the Commonwealth Council for Scientific and Industrial Research, which has established a number of specialized departments. The Royal Society, however, still retains the prestige of its Transactions and their distribution, which is frequently availed of for the publication of the results of investigations by workers in the C.S.I.R. laboratories and allied institutions, such as the Waite Agricultural Institute. It is to some extent the publishing body for the institutions it has helped to create, and always it has made no more than the modest claim to specialize in scientific work as it bears particularly on South Australia. This is reflected in the high proportion of Natural History in its accomplished work. The Society has made very valuable contributions in Anthropology by its many papers on the Australian Natives. This work has undergone a strong revival in recent years.

*Administration.*—The Society has always been governed by its own Council elected by the Fellows of the Society. It is affiliated with the Public Library, Museum, and Art Gallery. The chief points in this affiliation are that the Board of Governors of the Public Library, Museum, and Art Gallery find accommodation for the Society and its library. In return, the property of the Society becomes in a sense the property of the Board, in that nothing can be removed from the rooms allotted to the Society except by the consent of the Board. The Society elects one member to the Board of Governors.

The domestic relations between the Society and the Board of Governors have always been most cordial. The Society's influence on the Board in matters of the general policy of the Board is confined to that of one member in a large and mixed

body. It might be argued that its influence could with advantage be greater. However, I do not think this a proper occasion for me to discuss the affairs of the Board, though I might add that former Presidents have not always been of that opinion. Tate long ago said that the abnormal connection between the Museum and Art Gallery should be severed, as their interests are somewhat antagonistic. More recently one of the Society's representatives resigned on the grounds that in his opinion the Board did not subscribe to the ideals that must necessarily be those of the Society, and some other of our representative Governors have held similar views.

*Finance.*—The basis of the income of the Society is the subscriptions of members, and almost the whole of the expenditure is in publishing the Transactions. From 1879 to 1930 the Government subsidised the Society pound for pound on the amount of the subscriptions. From 1905 to 1930 an additional grant of £150 per annum was made towards the cost of printing. All subsidies ceased in 1930, reducing the Society's publication, that is to say its value to the community and to the world, in proportion to its reduced income. This year, 1936, the Government has been able to renew the grant, which is now at the rate of 50 per cent. of the cost of printing the Transactions, the amount not to exceed £200. The first payment of this grant, £151, has just been received, based on the Transactions for 1935. This is only about half the amount of former grants, but exceedingly welcome to the Society, and it is earnestly hoped that the Government will soon be able to return to the more generous scale of the past, which was in vogue for a quarter of a century, thus enabling the Society to produce its maximum results, and no longer forcing former contributors to seek publication outside Australia, to the loss of our credit. The essential binding of the Society's paper-covered series of exchange journals is almost hopelessly in arrear.

An endowment fund was founded in 1908 by the late Sir Joseph Verco, who was President of the Society for 18 years. His gift, and that of Mr. Thomas Scarfe, each of £1,000, formed the nucleus of the fund. Bequests from Mr. R. Barr Smith, Sir Joseph Verco and Sir Edwin Smith, and gifts from other generous benefactors, together with life members' subscriptions and occasional additions from the current account, have brought the fund up to almost £5,000. The intactness of this fund is now protected by by-law. The interest from it has enabled the Society to carry on through the lean years.

The Society is practically unable to give any financial assistance in aid of research. It was recently decided that the Endowment Fund must not be drawn upon, as had occasionally been done in the past, for this purpose, but that the Society's main resources should be conserved for publication, as the best means of encouraging research. At the same time a research fund was instituted, to which contributions from general funds of not less than £1 were to be made annually. The fund stands at present at £6, a farcical amount.

The Society makes one award for distinction in scientific work, and that is the Sir Joseph Verco Medal. The establishment of the medal in 1928 served two purposes, one the filling of a deficiency in the Society's functions, for it is a usual privilege of all societies of such standing as this to make awards in recognition of outstanding merit, and the other to do honour during his lifetime, and eventually to form a lasting memorial to the greatest benefactor and one of the greatest workers and most outstanding personalities in the history of the Society. The award is made for distinguished scientific work published by a member of the Society, and at such times as the Council considers there is a worthy recipient. Five awards have been made in the past seven years, to Professor Walter Howchin, Mr. J. M. Black, Sir Douglas Mawson, Professor J. B. Cleland, and Professor T. Harvey Johnston. In the future the Council of the Society will consider

recommendations for the award made by the holders of the medal, to ensure that the standard shall always be kept uniformly at the high level that is intended.

## The Future.

The Royal Society of South Australia is a very firmly established institution, whose existence seems likely to extend indefinitely into the future. It may be said to have thoroughly adjusted itself to its environment, as is shown by the remarkable stability and uniformity of its history for over half a century. Financially and numerically there has been little change. The membership has varied through the years between 100 and 200. At present it is 165. The policy has remained unchanged. Variety of activities has been its safeguard. There has been no high specialization, which proverbially leads to extinction. The Society cannot be said to encourage any particular science, though Natural History has always been a fundamental objective; yet, true to the traditions of its name, it has received in the past and always will welcome contributions in all branches of science, descriptive, mathematical or applied. Publication will tend to become even more the chief function of the Society.

As I have pointed out, it is no longer expected that the Royal Society should take a lead in such work as the exact sciences, or the applied sciences such as agriculture or engineering. Other institutions are better equipped to do that. But I would suggest that the Society might take a more active part in directing and encouraging original work in the descriptive sciences, which still remain the special province of the Society, by setting forth from time to time the trend of research work in those branches of science, and particularly by pointing out the departments which are suffering from neglect. I hope my colleagues, who have so readily agreed to assist me in this Centenary review, may establish a precedent in this respect.

*The Library.*—Our library, accumulated through the 83 years of our unbroken exchanges with other learned societies, now contains a very large and varied collection of scientific journals, complete in the case of many journals and unique in some. Both its intrinsic and scientific values are high. Yet this library has never been the asset to scientific workers that it should be. It has never properly fulfilled its purpose, and has been a source of worry to the Society throughout its whole history. Accommodation has been one of the troubles, supervision the other. The plain fact is that the Society has never been able to afford the library it set out to provide. The accommodation is sufficient at present, with the main part of the library in the room in which meetings are held, and the overflow, consisting chiefly of spare copies of our Transactions, in a room kindly put at our disposal by the University in the old police barracks buildings at the rear of the Museum, and cut through by the line separating University property from that under the control of the Public Library, Museum, and Art Gallery. The whole library has been re-arranged during the year, mainly by our Secretary, Mr. N. B. Tindale. However, the question of availability is no further advanced than it has ever been. The library is only open on one afternoon each week, in addition to the half-hour preceding the monthly evening meeting. A scientific library that can only be entered once a week is suffering under a tremendous handicap. The worker will search anywhere else sooner than wait for the day on which our librarian is in attendance. The result is that the only books used are the ones that cannot be obtained elsewhere, and then the users may have to wait a week to get them.

Until the Society was housed where it is today, in 1907, the library was nothing but a burden to it. The Annual Report of 1890 states: "Your Council is far from satisfied with the present conditions under which the books have to be kept. It had hoped that by this time arrangements might have been made to have

had them so placed in some portion of the Public Library that members could have had access to them at any time during the day. The Council feels that the present unsatisfactory condition cannot be allowed to continue, but that every effort must be made to place at the disposal of the Fellows the library in a more efficient way." This report was quoted by Dr. Rogers in 1922, and reappears today. The situation has not been met during the past 50 years. In 1901 a special committee recommended that the only solution was to transfer the books to the Public Library, which was not acted upon. In 1906 Sir Joseph Verco said, "In order to be useful they (the books) must be accessible and convenient for reference. This they have not been for many years, if they have ever been." Will the same report be made 50 years hence?

At all times the Fellows of the Society have been very much against handing the library over to any other body, so that its identity should be lost. The continuity of the journals received through our system of exchanges must never be broken. Another fact which deserves attention is that the value of the library lies almost entirely in the journals. No text books have been purchased for many years, and what we have are of little more than archaeological interest. The general scientific literature has never been anything like complete in any section. We would save space, at no real loss to ourselves, by getting rid of all our books except the journals, and I would recommend that they be presented to the Public Library forthwith. This would leave our library with a definite character, a continuous series of certain scientific periodicals, always increasing in number and diversity. I would further suggest two alternative ways in which this reconstructed library could satisfactorily be dealt with. The first is that it should become a section of some existing library, where its books would be separately housed, and distinctively marked as part of the library of the Royal Society of South Australia, yet available to a larger section of the community. Fellows of the Society would enjoy the privilege of taking books out of its section. Either the Public Library or the University Library could very satisfactorily carry this out, and owing to our relations to the Public Library, Museum, and Art Gallery, the Public Library would appear more suitable.

The second alternative is that the Society should sever its connection altogether with the Public Library, Museum, and Art Gallery and seek new accommodation. This would seem at first sight impossible on the score of expense. It would certainly require the consent of the Board of Governors. However, I believe this to be the solution to aim at.

## A Science House.

We should have in Adelaide a building similar to Science House in Sydney. There the majority of scientific institutions are housed in one building. The land was presented by the Government, and the building was erected at a cost of £43,000 by the three owner bodies, the Royal Society of New South Wales, the Linnean Society of New South Wales, and the Institution of Engineers, Australia. Each bore one-third of the cost, and at the present time they are getting a return of 4 to 4½% on their capital outlay. Eleven societies have their headquarters in Science House, Sydney. The advantages of such a building are too obvious to detail in this address, but I will refer especially to the library, a small matter in a much larger field. The libraries of all the tenant societies could be grouped together and one librarian, with probably other secretarial duties as well, could be constantly in attendance and take charge of them all.

Adelaide could begin in a more modest way than Sydney with its six-storey building, and the cost might well be raised by a group of societies. I have good reason to believe that the University would take a very sympathetic view of a

suggestion that such a building should be erected on the University grounds, which would be a most happy and excellent solution of the problem of a site and its purchase.

I would recommend that this Science House project should be pursued before any further steps are taken about our library, for it is a much bigger thing, and carries the library with it.

## Conclusion.

This address has been of a general character and has made little reference to the progress of work in particular branches of science.

In my analysis of the papers presented before the Society during its whole existence, I classified them under the five headings: zoology, geology, botany, exact sciences and anthropology. I mention them in the order of abundance of papers submitted in each group. It was the Council's desire that addresses on each group should be given during the year by leading authorities in each, to which my address would be introductory. These addresses will be in the nature of reviews of past work in each subject, particularly as it affects South Australia, and with special reference to the part the Royal Society has played, and will, I hope, make suggestions for the guidance of future work. I have suggested such titles as One Hundred Years of Botany in South Australia. Zoology has been divided into two sections, separating entomology from the remainder, and botany will be dealt with from two aspects, systematic, which represents the side which has mainly occupied the attention of our workers, and physiological. I am very pleased to be able to announce that the future addresses will be given, at dates to be arranged, by Professor T. Harvey Johnston on general zoology, by Dr. James Davidson on entomology, by Sir Douglas Mawson on geology, by Professor J. G. Wood on botany, by Mr. J. M. Black on systematic botany, by Professor R. W. Chapman on the exact sciences, and by Dr. T. D. Campbell on anthropology. They are each very distinguished Fellows of the Society in their particular subject; three are Verco Medallists, and four are Past Presidents of the Society.

# CENTENNIAL ADDRESS-NO. 1.
# BOTANY.

*BY J. G. WOOD, PH.D., D.SC.*

## Summary

The story of Botany in South Australia since its foundation has been a relatively simple one. It has been concerned almost entirely with the accumulation of a complete flora of the State; that is to say, of descriptions with reference keys to the species which make up the plant covering. Such a procedure is a natural and an essential one in a new country. But from the point of view of the science of Botany it is only a preliminary, not an end in itself, though it provides a means to an end. It is convenient to distinguish plants by names just as it is convenient to distinguish Bill Jones from Tom Smith. The collection and naming of angiospermous plants in South Australia is now almost complete. Its history may be adequately written, and this will be done at a later date by one more competent to speak of this aspect than I.

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The history of the other branches of Botany, and which constitute the bulk of the subject, may be dismissed in few words so far as South Australia is concerned. For one thing, their histories have been largely the history of the science itself, which is not local, and, for another, professional botanists in Australia are so few. Consequently, it is something in the nature of a stocktaking that I shall make tonight, and consider not so much the past as those outstanding gaps in our knowledge which seem to me to require filling in the future.

The divisions of Botany fall into two groups—the descriptive and the experimental branches. To the former belong morphology, anatomy both gross and minute, cytology and palaeontology; to the latter physiology, genetics and ecology. These subdivisions of Botany are often studied separately, often for convenience, sometimes from lack of a broad vision. In this way the essential unity of the science and the broad generalisations which shall form the basis of the science are apt to be lost sight of.

I do not wish to consider the various subdivisions separately, but to view them from another angle. We can picture any living organism as an equilateral triangle, having its being and maintained by three things. One side of the triangle we can label "What it is," another "What it has," and the third side "What it does."

First let us consider what plants are in themselves; obviously a species is more than a name. The coming years will doubtless see the dead bones of classification revivified. I do not mean by the addition of new species. Biological classification has the merit of resting on one broad generalisation—the idea of evolution or change. We think that the doctrine of descent gives the key to a perfect system; and an arrangement of plants is more or less natural according as it brings out relationships. Our present systems are far from perfect ones mainly because they are based on external morphology alone. Not until we study the minute anatomy and cytology of plants and especially use the experimental breeding methods of Mendel, will we be able to devise the perfect system which will be no mere convenient device for finding the name of a plant, but a definite achievement embodying two of the greatest generalisations made with respect to living organisms—the idea of change and the idea that heritable characters act as units which segregate on breeding.

In South Australia the anatomy of only a few native plants is perfectly known, the cytology of none and the genetics of one or two native grasses. In other parts of the world beginnings have been made, but much remains to be done. It is hack work, but interesting to some types of minds, and its synthesis will reap a rich reward. I would not wish to see one branch studied alone, but in conjunction with the others. I have considered here only the scientific aspects, although the economic ones are not negligible—the varieties of some native grasses and common saltbush species spring to my mind—for the more one studies the flora the more complex becomes the mixture of biospecies, hybrids and ecotypes, which all masquerade under the name of "species."

Our system must consider not only the present but the past. The Tertiary floras of Australia as a whole are practically unknown to us. Yet it is from these that we shall learn most, since it is the Angiosperms, the plants of modern times, which concern us particularly. The great group of the Pteridophyta is one which might serve as an example to us and in which phylogeny, palaeontology and anatomy have been carefully studied.

The other groups of plants lag far behind. Let me state that not even a census exists of the freshwater algae, of the mosses and liverworts, of the lichens or of the bacteria. Nor are the saltwater unicellular algae known.

Yet these are interesting plants, and they lead us at once to my second grouping of what the organism has—the effect of environment upon it. The lower plants appear to be practically cosmopolitan in their distribution. It is the environment which selects. From a handful of garden soil one can, by suitable cultures, obtain bacteria and algae listed only, say, from Tanganyika or Burmah. Our future studies of the lower plants of South Australia which I have mentioned must be accompanied by careful quantitative studies of the factors of the habitat, if they are to be of any use.

The higher plants—the Gymnosperms and Angiosperms—which are not reproduced from light and easily carried spores are obviously more restricted; otherwise there would be no need for local floras. Nevertheless, they also occur in definite groups or communities which live naturally together. The study of these communities is termed Ecology or Plant Sociology. It attempts to find out the laws which determine the maintenance and change of these communities, for the communities act as units. The factors which determine the presence of any particular community are mainly environmental—especially meteorological factors, soil factors and biotic factors such as the influence of other plants, or animals or man. Partly, also, the physiological make-up of the plant is important, especially in extreme climates. The environment here has exerted a sifting effect and only plants with specialized mechanisms, either structural or metabolic, can survive when a migrating population of species invades such a habitat. The background required for these studies is a broad one, embracing, as it does, several sister sciences.

In this State, so far the only one in the Commonwealth, the chief communities have been described, and these will shortly be published. The work is, however, mainly descriptive, as such reconnaisance work must necessarily be. Only in a few cases has the environment been described adequately. The task will be a long one.

From a scientific point of view, the major interests are the broad generalisations concerning the direction of change and the nature of the conditioning environment; but again the economic aspects are not to be neglected. A topical example is the problem of drift and soil erosion in the northern areas of this State, which is now distressing many people. The problem is mainly one of the management of grazing animals on a plant community which is nicely balanced with its environment. Robert Bridges in that great biological poem, "The Testament of Beauty,"

adequately describes the relation of organisms to their environment and metabolism:—

*"All Life's self-propagating organisms exist*
*only within a few degrees of the long scale*
*rangeing from measured zero to unimagin'd heat,*
*a little oasis of Life in Nature's desert,*
*and ev'n therein are our soft bodies vext and harmed*
*by their own small distemperature, nor could they endure*
*wer't not that by a secret miracle of chemistry*
*they hold internal poise upon a razor edge*
*that may not ev'n be blunted, lest we sicken and die."*

In the North the razor edge has been blunted—by wool. In Queensland, as also in other parts of the world, indiscriminate burning of plant communities, especially grasslands, without understanding their nature and the laws that govern them, has resulted in complete deterioration of the communities. In South Africa there is a Government Department of Plant Survey which is making a complete vegetation survey before utilizing any new country.

Finally, we come to the question of what plants do—the realm of Plant Physiology. This is an exact quantitative science, utilizing the methods of physics and chemistry. It attempts at present to trace the course of metabolism and explain the behaviour of plants in terms of physico-chemical laws. It is a young and vigorous subdivision of Botany and has been limited in the past by lack of adequate analytical methods, and also of adequate statistical methods for dealing with the material.

Already we know a great deal about some fundamental processes like photosynthesis and respiration. It is paradoxical, however, that the best known practical application of economic importance—that of manuring—has been least studied from the point of view of utilization and metabolism in the plant itself. Already in this State beginnings have been made with such problems of nutrition and their effect on development which should lead to important conclusions. Beginnings have been made also on the problems of drought resistance, a question of the greatest importance to an arid State like South Australia. Problems in this field are legion, and will be fruitful of results.

For ordinary practical purposes in physiology, as in physics and chemistry, the old physical conceptions as developed along the direct lines from Newton and Galileo will continue to be employed. But the science of Biology, of which Botany is a part, will grow as the science of Physics grows. The living plant is not like inorganic matter—it lives, it grows, it reproduces itself. It is an expression of ceaseless co-ordinated activity. On the Newtonian concept the physical universe consists of essentially inert and unco-ordinated units of matter; but to the new Physics an atom, or an electron, is also an expression of ceaseless co-ordinated activity, and incapable of interpretation in mechanical terms as a mere particle. The boundaries between the living and the non-living are slowly breaking down.

I have finished my all too brief survey. The achievements of the last one hundred years have been amazing—in fact, they constitute the whole history of the science of Botany. The things to be done in the future are also bewildering in their number, but we have this consolation: we are standing on the margin of a rich and fertile field. The future will be the Age of Biology.

# CENTENNIAL ADDRESS-NO. 2.
# ANTHROPOLOGY AND THE ROYAL SOCIETY.

*BY T. D. CAMPBELL*

### Summary

Everyone is aware that the occupation and settlement of this country necessarily meant the taking of the aborigines' homelands, and perhaps the ultimate elimination of the natives themselves. Thus the founders of this Colony and its settlers were, and its present inhabitants are, charged with a grave moral and national responsibility. One may perhaps be excused for stressing again that the founders of the Colony of South Australia were not ignorant of the problems involved in settling territory occupied by a primitive native race. The British had long since been colonizers in native lands, and by 1836 other parts of this continent had already been occupied for a number of years. Moreover, it is obvious that the British Government was aware of this particular responsibility of settling South Australia and the possible clash of peoples; for, as has elsewhere been pointed out, the Government was so acutely aware of the grave responsibility involved that more than half of the proclamation which Governor Hindmarsh issued at Holdfast Bay, one hundred years ago, consisted of an exhortation and warning to the settlers concerning the friendly and just treatment they were to adopt towards the aborigines.

## CENTENNIAL ADDRESS—No. 2.

# ANTHROPOLOGY AND THE ROYAL SOCIETY.

Dr. T. D. Campbell.

[Read July 9, 1936.]

Everyone is aware that the occupation and settlement of this country necessarily meant the taking of the aborigines' homelands, and perhaps the ultimate elimination of the natives themselves. Thus the founders of this Colony and its settlers were, and its present inhabitants are, charged with a grave moral and national responsibility. One may perhaps be excused for stressing again that the founders of the Colony of South Australia were not ignorant of the problems involved in settling territory occupied by a primitive native race. The British had long since been colonizers in native lands, and by 1836 other parts of this continent had already been occupied for a number of years. Moreover, it is obvious that the British Government was aware of this particular responsibility of settling South Australia and the possible clash of peoples; for, as has elsewhere been pointed out, the Government was so acutely aware of the grave responsibility involved that more than half of the proclamation which Governor Hindmarsh issued at Holdfast Bay, one hundred years ago, consisted of an exhortation and warning to the settlers concerning the friendly and just treatment they were to adopt towards the aborigines.

Clashes followed and problems arose; and present-day interest and discussion shows that the same problems are still with us.

What bearing has the science of anthropology on this matter of our aborigines and the problems arising out of our occupation of their country? Anthropology as a purely academic study has been mainly concerned with investigations on the physical and cultural history of the various types of mankind, and in particular the more primitive races. For a long time it remained so. But in more recent years the occupation of native territory has ceased to be merely oversea adventure with spasmodic trading; it has become what we now hear described as empire expansion, demanded by the pressure of social economics and national pride. The closer study of native races has become something more than scientific curiosity. We now have what is sometimes termed "applied anthropology," occupying an important place in the training of colonisers, administrators, officials and missionaries, whose work takes them into native territories. And so we must look on our own anthropology as a study which concerns not only the serious-faced individuals who read papers before this Society, but something which can and does become closely associated with certain important problems of our State.

Let us now briefly review the study of the indigenous inhabitants of our own territory. On account of the geographical association and the fact that for a long time it was part of this State, I shall include that portion of the Northern Territory now spoken of as Central Australia. For convenience we may roughly divide our survey into four arbitrary periods.

Until about the middle of last century, much of the data recorded on the aborigines was merely incidental observation appearing in historical writings and Government reports. Not that their occurrence in this manner lessens their value as anthropological records; for they help towards our far too meagre fund of information on the aborigines as they were at the early stages of settlement. And while this form of record may not have attained the importance of a scientific

anthropological treatise, many of them are the impressions of shrewd observers and careful writers, and they are, therefore, eagerly studied and highly valued by present-day workers. However, let it not be thought that in those early days there was none sufficiently interested and capable to record with scientific detail data on the natives. Only a few years after the foundation of the State, in the forties, some extremely valuable publications were produced on native life and customs. A number of these were on the languages of various groups; no doubt the outcome of serious attempts to master speech with the natives. We shall ever remain thankful for the works of Williams, Tieckelmann, Schurmann, Eyre, Meyer, Moorehouse, and Angas.

By the time the second half of the century was on its way, mission stations and aboriginal reserves of varying size and importance had been established to preserve and look after the remnants of the rapidly diminishing aboriginal race. With the close contact these means provided, a number of workers, either associated with mission work, or as observant police officers in outback stations, wrote up their notes and have left an extensive and valuable fund of information. Chief among these, one might mention some names which readily come to mind; such as Taplin, Wilhemi, Cawthorne, Wyatt, and Wood; Gason and Willshire in the far North; Mrs. Smith in the far South-East.

Then towards the close of the century was commenced that remarkable association of two outstanding workers, Spencer and Gillen, leaving for us that classic legacy of tremendously detailed information on the aborigines of the Macdonnell Range region. It is probably owing to the brilliance of Sir Baldwin Spencer as a scholar, a teacher and a writer that the importance of Gillen's place in that remarkable partnership is apt to be overshadowed and underestimated. Gillen not only conversed with the natives in their own tongue, but his observations were so detailed and illuminating that his original notebooks reveal the fact that much in the famous volumes consists of a straight-out transcription of Gillen's own notes.

About the same time the late Sir Edward Stirling, on the Horn Expedition, laid the foundation of his fine anthropological work; and he set out to collect and preserve for all time objects associated with the cultural and industrial life of the natives. The exhibits in the Stirling Gallery of our Museum, and the mass of material not on display, are not only a wonderful monument to his name, but probably the finest collection in the world of ethnological material of the Central Australian Aborigines.

And from then onwards to the close of last century, and during the first twenty years of this century, research and collection of data became more intensive and more specialized. It was possibly owing to the fact that the social organisation of our aborigines was becoming more appreciated as an extraordinary, complex and specialized business that sociological studies were attacked with such vigour.

To the names of Spencer, Gillen and Stirling must be added those of others who devoted considerable time to the study of the native; men like Strehlow, senr., Reuter, Krause, and Howitt. But, in addition, we have others who have added valuably to our knowledge: Ramsay Smith, Mrs. Bates, Herbert Basedow, and our present member, Mr. J. M. Black.

We come now to more recent years. The methods of anthropological research have undergone rapid improvement, refinement, and specialization. The advent of Professor Wood Jones was an important factor in making the early twenties another outstanding time mark in anthropological interest in this State. It was largely due to Wood Jones' infectious enthusiasm and methods of critical observation that he was such a stimulating influence on workers about him. There arose a recrudescence of anthropological interest in and from Adelaide. The Anthro-

pological Society of South Australia was founded. The University Council established a Board for Anthropological Research, and gave anthropology an official standing in the University. The South Australian Government was persuaded to contribute its quota towards the establishment of the Chair of Anthropology in Sydney. The post of Ethnologist was created at the South Australian Museum.

During the later twenties were inaugurated field expeditions to Central Australia and various parts of South Australia. These expeditions, under the direction of the Adelaide University—with whom the S.A. Museum readily cooperated—have for the last ten years been an annual event, and have been the means of amassing and collecting a considerable amount of valuable and original scientific data and material in the form of ethnological objects, photographs, cinema films, and phonograph records. This expeditionary work has received its chief financial support from American funds provided by the Rockefeller Foundation and administered by the Australian National Research Council. But we are fortunate in this State, probably alone among all the States, in that we have also received private financial support towards this research work.

This hurried survey of anthropological studies during the hundred years of the State's history shows that, from the commencement of the Colony, its original possessors have been of considerable interest not only to scientific enquirers, but also to those observant folk who were so keenly interested in happenings about them that they took the trouble to record what now is to us very valuable data. And even if we are forced to admit almost complete ignorance of the life and customs of natives who lived in many parts of our State, we can at least feel thankful for all that has been done.

Let us now turn for a few minutes and see in what way our Society has interested itself in matters aboriginal. Although this Society dates back only to 1879, actually it existed under other names for many years prior to that time. In fact, an ancestral line can be traced back to the very beginning of the State. Whether or not the Statistical Society of South Australia was connected with our Society's ancestry, it is interesting to note that as far back as 1842 there was a Statistical Society here, and it actually published in its transactions a report on the "Physical appearance, habits of life, ceremonies, superstitions, numbers and language, etc., of the aborigines of South Australia." This is probably the first record of a local society publishing data on the aborigines.

So far I have not been able to trace other anthropological papers in our records prior to the Philosophical Society, which was the immediate forerunner of this Society. But in the Transactions of the Philosophical Society there are seven papers on anthropological matters. After this Society had become the Royal Society, there was an average of about one anthropological paper a year for the remainder of the century.

During the first twenty years of this century, we find only about seven or eight papers were printed. But it is interesting to note that in 1915 a long and important paper by the now well-known Malinowski was published by our Society. In the early twenties commenced the modern outburst of interest. During the last twelve years, an average of about three anthropological papers a year have been published. Since the Society has been publishing its journal, a total of 74 papers of anthropological type have been printed. This includes several short articles of interest and two Presidential addresses which were definitely anthropological.

We can safely say that while this Society has not had the financial means for directly supporting anthropological work in the field and on living natives, it has, by its continued policy of publishing almost without exception every anthro-

pological paper presented to the Council, shown a keen sympathy towards this aspect of its activities.

We are now brought to the question which is doubtless asked by some: Of what use is this century of observation and publication on the aboriginal inhabitants of this country?

I will remark firstly on the purely academic viewpoint, not because it is necessarily the most important. In the Australian aboriginal people we have, still existing in some parts of our country, a modern living example of stone-age man —a primitive race which to anthropologists is one of the most interesting groups of mankind on the earth. With the spread of civilization to almost all parts of the globe, some of these interesting primitive peoples have passed away with little or no written record of their life and habits having been made. These are the unwritten chapters in the history of mankind, pages on which the moving finger has written nothing, or at the most has paused to enter but a word or two. For the most part these pages must remain for ever blank. Thus the anxiety of anthropologists in Australia, and even visiting workers from overseas, to place on record as much as possible concerning our Australian natives, and avoid for example, the stigma and regret which remains concerning the long since extinct Tasmanian race.

But this is not the only purpose in studying their life and habits. I have already referred to what might be termed applied anthropology. Clashes between settlers and indigenous inhabitants, unfortunately, seem to be inevitable. But a closer understanding and sympathy towards the natives' life and viewpoint surely helps to soften and lessen these clashes. It is only by a careful and intelligent study of the native, his mode of living, his social organisation and mental make-up that the correct sympathetic and reasonable outlook can be acquired, and the necessary compromises and adjustments effected.

After a hundred years, we have at our disposal accounts of the earliest contacts with native life and the difficulties encountered. We have the records of mission activities, of attempts at civilizing and educating the natives; we have the reports of protectors, of police officers, and a wealth of publications on native life and customs. And yet today, knowing all these things, we still seem to be floundering with precisely the same problems which confronted South Australians one hundred years ago. Australian soil was once occupied by these dark-skinned folk who, by our standards, are exceedingly primitive and crude; yet they at any rate carried on a completely successful economic and possibly happy existence in this country. Their homeland was, and still is, being filched from them, and in return they have received, for the most part, only our villainies and vices. It would be a bold opinion that would assert that a fair deal had been given them. Governments, missionary efforts, so-called protection, national pride (if any) and even the oft-proclaimed Australian spirit of good sportsmanship and fair play all seem to have failed. It is high time that we Australians faced up squarely to the simple and obvious question. Is the lingering remnant of this interesting and simple people to be preserved, or is its present rapid and deplorable elimination to proceed on its way? Any straightout answer to such a statement seems to be one which we as a State and a Commonwealth have avoided with a disconcerting persistence. Occasional voices are raised in protest, but apparently they might just as well cry out in the sandy wildernesses which we have allotted to the natives, for there they might possibly arouse the curiosity of some aboriginal nomad.

Reserves in the full sense of the term should be established and controlled solely for the benefit and preservation of the aborigines. We know definitely that in those regions where the native is still alone and not interfered with he thrives and gets along quite happily. Or, on the other hand, if his rapid passing is to be tacitly accepted, at least some adequate method should be adopted to make his

passing a respectable and comfortable one. Neither of these courses has yet been seriously attempted. Some folk are aware that a large so-called reserve does exist on the map; a few know that little serious attempt has been made to make the reserve a genuine controlled preservation. In fairness, one is forced to mention the recent gesture of the Commonwealth in appointing our own Strehlow, junr. to the post of patrol officer.

To conclude these remarks, I will summarize by saying that concerning our aborigines we still find ourselves with two important unfinished jobs. Firstly, the one of pushing on apace with studying and recording as much as possible the life and customs of the natives in a careful, broad and scientific manner, not only out of scientific curiosity, but also for the practical value of the work. The other is a more honest endeavour to ensure the preservation of this interesting race. The Royal Society is not expected to solve all the problems involved. But these remarks are an endeavour to indicate what the Society has done and what it might further do. I have already outlined the excellent service the Society has performed in the publication of anthropological papers. For a moment I want to revert to the year 1898. At the ordinary meeting of this Society on July 5, 1898, Dr. Stirling moved, and Professor Tate seconded:—

"That whereas the aborigines of Australia are rapidly disappearing it is desirable, in the interests of science and of our successors, that a comprehensible and enduring record of the Australian race, in the fullest anthropological and ethnological significance, should be undertaken before it is too late; that this Society communicates with the Royal Societies of Victoria, New South Wales, Queensland and Western Australia and the Linnean Society of New South Wales with the object of asking whether those societies will join in a combined movement, together with such other scientific bodies as may be interested, to induce the Governments of their respective colonies to promise contributions of say £500 from each colony, payable in such annual instalments as may be necessary to defray the expenses of such work; that contingent upon the approval by this Society of the above resolution, the Council be requested to put it into effect by forwarding copies to the bodies mentioned."

At the Annual Meeting, October 4, of the same year, the Presidential Address was given by Dr. W. L. Cleland. This address referred to the important resolution passed at the July meeting, and was almost entirely concerned with remarks on the Australian aboriginal race and the desirability for vigorous and co-ordinated research. Dr. Cleland stated that:—"There is every reason to hope that material assistance will be obtained from the various Governments for effectively carrying out this national work, and it will also be conceded by all that no time should be lost in setting about the collecting of all available information."

Since that time our Society has certainly done some useful work in attempting to fulfil the hopes of our predecessors. What reply the Society received from the circularising of the important resolution I have not so far been able to ascertain. Nor do I know whether the optimistic hopes of Dr. Cleland concerning Government assistance were realized. Perhaps the assistance extended towards the Sydney Chair of Anthropology was a belated move in this matter.

This Society is associated with the University Board for Anthropological Research, for at present four of its Council members are also members of that Board. Let us hope that this association will continue; and I feel sure that if the matter were taken up the University Council would readily agree to the Royal Society being officially represented on its Research Board.

Another point. The importance of a thorough knowledge of aboriginal life and customs, and an appreciation of his mentality and viewpoint is so well recognised that it seems to me desirable in the light of the interest this Society takes

in these matters, that it should be officially represented on the Government Advisory Council on Aborigines.

My next point is perhaps not so much a constructive suggestion as a criticism. It seems peculiar that that fine institution, the South Australian Museum, which possesses such a wealth of anthropological and natural history material, should have on its governing committee such inadequate numerical representation of these sciences. At present there is definite provision for only one member likely to be expert in natural history and scientific questions.

Our President pointed out that in days past and before this age of marked specialization, this Society often acted in an advisory capacity and deputised the Government on various State problems. The matter of really awakening to our national responsibilities regarding the aborigines seems to involve the problem of generally arousing and educating public and Government sentiment.

I want to make a brief interpolation. Recently a young archaeologist, Mr. Movius, was in Adelaide on a visit, and one evening gave at an Anthropological Society meeting a very fascinating little lecture on his archaeological work in Palestine, where he was associated with some excavatory research in which some Neandertaloid skulls of great interest were unearthed. The remark which stood out among his very interesting statements was to the effect that in that country, as soon as any excavatory work, quarrying or digging of any sort, brought to light any finds of archaeological interest, the Government immediately proclaimed the spot a national reserve and it was properly controlled and protected.

Perhaps this Society, as one of the few institutions interested in anthropology, could, with benefit, occasionally raise its authoritative voice in an endeavour to stir up the conscience of the people of this State on the matter of its responsibilities towards the remaining aborigines and their interesting relics.

# CENTENARY ADDRESS-NO. 3.
# THE PAST WORK OF THE ROYAL SOCIETY OUTSIDE THE DOMAIN OF NATURAL SCIENCE

*BY PROFESSOR R. W. CHAPMAN, C.M.G.*

**Summary**

A review of the work of this Society in those branches of Science which lie outside the domain of what are commonly known as the "Natural Sciences" appears at first glance to be an easy task. For a perusal of the tables of contents of the published volumes of the Royal Society shows that the number of papers coming under this category is very few indeed. One seeks to collect the flowers to press and preserve in the herbarium, only to find that these particular plants have almost refused to flower. The total number of papers published in the Transactions since the first volume was issued in 1878 is roughly 900, and out of these only 65 deal with Physics, Chemistry, Mathematics, Astronomy or Engineering. The reason for this is not that there has been any marked shortage in South Australia of able and enthusiastic workers in these departments, but that most of the important research contributions in these sciences are naturally sent to those more specialized papers or societies which devote themselves to the particular interests of one of these branches of knowledge. Such an eminent mathematician as the late Sir Horace Lamb, for example, who wrote his classical work on "The Motion of Fluids" while he was a Professor at the Adelaide University, is represented in the annals of this Society by only two small contributions, one on "The Persistency of Electric Currents in Masses of Iron," and the other on "The Causes of Luminosity in Flame," both on Physics. The great field of Mathematics is represented by a single paper by Prof. Wilton on "Certain Diophantine Problems," contributed in 1920. The chemists and the physicists and the engineers have obviously preferred, for the most part, to send the records of their researches to periodicals with a wider circulation amongst those interested in their own branch of work and where their fellow-workers in similar fields in other parts of the world will be most likely to seek in order to find the latest contributions to knowledge in those domains. Thus it has come about that our S.A. Royal Society has become more and more the repository for new knowledge in the Natural Sciences, particularly as displayed by the rocks, the flora and fauna, and the natural phenomena of South Australia. However much this may be regretted by those who would like our own Royal Society to emulate the catholic sympathies of the parent Royal Society of London, which encourages contributions from every department of human knowledge, it does not seem at all likely that this measure of specialization can be avoided. Modern knowledge is developing so complex a growth that more and more it becomes essential to have specialization not only among' scientific workers but in the literature and the societies which provide the means of intercourse between those labouring in any single field.

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The Reports of the Adelaide Philosophical Society, before the days of the publication of an annual volume of Transactions and of its blossoming out to become the Royal Society of South Australia, show that in those early days there was no such bias towards the Natural Sciences as the Royal Society has since developed. Its papers and discussions ranged over the whole field of human thought, from literature to science, from philosophy to problems of practical engineering. The Rev. J. Maughan, in a paper which he contributed on August 15, 1865, on "The Drainage of Adelaide, Considered in its Scientific Aspects," remarked in his introduction that "However important it may be to explore the

various ramifications of natural phenomena, it is still more important to bring the teachings of science to bear upon questions of public utility. To deal amply and elaborately with things theoretical, and sparingly, or not at all, with those that are practical, would be as little accordant with the spirit of true philosophy as with the characteristic tendencies of the age in which we live." And the Society seems to have lived up to the ideals thus eloquently expounded. Taking the first six papers read before the Society, in 1853, the first was on Meteorology, the second on "The Theory of the Arch," the third dealt with "The Mathematical Theory of Musical Harmony," the fourth with "The Rise of English Comedy," the subject of the fifth was "The Structure and Uses of the Hand," and the sixth "The Structure of the Aboriginal Dialects of New Holland." The menu provided certainly did not lack variety, and there was little danger of the members suffering from a lack of some particular vitamins because of the monotony of their fare. But at that stage in the colony's history it was not to be expected that much original scientific research could be done. The population of the whole of South Australia in 1853 was only about 75,000, most of them actively engaged in the pioneer work necessary in a new country, and there were few people with either the training, facilities or opportunities for much in the way of scientific investigation. On the other hand, the Society was undoubtedly from the first a helpful mental stimulant to the community, and its influence in the moulding of public opinion and public policy was strong. Important public questions were frequently discussed. Before Mr. B. Herschel Babbage set out in 1858 on an exploring expedition past the western side of Lake Torrens, he discussed with the Society what he proposed to do. In 1870 Mr. Charles Todd brought before the Society his plans for the building of a telegraph line across the continent, from south to north. "The Drainage of Adelaide" was a subject to which attention was first called by a paper from Mr. Babbage in 1856. The Rev. J. Maughan brought it up again in 1865. In 1866 there were three papers on the subject by Messrs. J. Macgeorge, J. Allen and B. H. Babbage. And in the Report for 1867, it is stated that at the close of the discussion on the subject of Drainage the following resolutions were adopted:—"That this Society desires to impress upon the authorities of the City of Adelaide the importance of taking prompt measures for: 1st, An organised system of scavenging for the removal of the solid refuse of the City; 2nd, The absolute prohibition of cesspools in those portions of the City which are supplied with sewers; 3rd, The construction of sewers in the centres of streets, in place of under the footpaths, of sufficient depth to drain the cellars of the City; 4th, The arrangement of such a system in the construction of all sewers as will enable the sewage to be ultimately conducted to a distance from the City, and as far as practicable utilized by some process of irrigation or otherwise." A memorial embodying the resolutions was consequently prepared and forwarded to the City Council. It was but a few months later that a Bill was introduced into the Legislature to enable the Corporation to commence a system of deep drainage. On such questions amongst the contributors to discussion in the Society were leading public men, and the Society was thus enabled to exert a wholesome influence on matters of great importance to the community. In the sixties the question as to whether a sparsely populated country should be developed by building the more solid but more expensive railway lines on the 5 ft. 3 in. gauge or lighter and cheaper lines on the 3 ft. 6 in. gauge was one on which engineers themselves were divided. It was one on which South Australia had to come to a decision for carrying the railway out into new areas on which only a small population was to be expected for many years. Four papers read before the Society, with appropriate discussions, show the interest that was taken in this big question. There were two papers on this subject in 1867, one by Mr. J. Macgeorge and the other by Mr. W. Hanson, and two more in 1870 by Messrs R. C. Patterson and A. F. Lindsay. These were

apparently backed up by vigorous discussion which has, unfortunately, not been recorded, but three out of the four papers advocated the construction of narrow gauge lines on the 3 ft. 6 in. gauge. Whether the discussions had any direct influence upon the Government policy it is impossible to say, but during the next few years, in the seventies, a change was made from the broad gauge of the earlier lines, and isolated light railways on the 3 ft. 6 in. gauge were pushed out from Port Augusta, Port Wakefield, Port Pirie, Beachport and Kingston to bring the products of the country to the seaboard. These formed the basis of our present narrow-gauge system.

During the lifetime of the Adelaide Philosophical Society education in South Australia was compulsory but not free. The Central Board of Education had power to grant licenses to teachers, and to pay them out of State revenues salaries ranging from £40 to £100 per annum in addition to the fees paid by the parents of the children. The system of public education was one that we should regard now as totally inadequate, and it was not until 1875 that a big forward move was made by giving over the management of public schools to a Council of Education under the presidency of a competent paid Inspector-General. Education was, therefore, naturally a subject that interested members. There were two papers dealing with the subject in 1868, one by Mr. T. S. Reed on "Education of the Working Classes," and the other by Mr. James Hosking, entitled "Education in South Australia." In both of these papers the establishment of free schools was advocated. It was stated that enquiries had shown that there were then at least 1,000 children in the City of Adelaide who were not attending any school because of the inability of the parents to pay the necessary fees. Mr. Reed, in his paper, said that one man had told him, "I have ten children who can't read or write. I can't read or write myself; why should they?" No wonder that the subject aroused the interest of the Society. There were two more papers in 1871, both by Mr. Hosking, on "Educational Legislation," which, judging from the abstracts which are preserved in the records, promoted a vigorous discussion. The discussion was, however, severly hampered by the fact that according to the rules of the Society any debate on either political or religious subjects was forbidden, and speakers were continually brought to order by the Chairman for transgressing the law.

The last report of the Society, before the advent of the present form of the Transactions, at the end of 1871, winds up on a very familiar note, "The Council," it says, "would take this opportunity of urging upon members the necessity of paying their subscriptions punctually. During the past year, out of 62 ordinary members only 34 have paid their annual subscriptions."

Coming now to the published Transactions in their present form, which in the third volume became the Transactions of the Royal Society of South Australia, we find two papers contributed in 1887, one by Dr. Jamieson and the other by Dr. H. Whittell, dealing with the "Drainage of Adelaide and its Influence on the Death Rate," which form a very satisfactory conclusion to the discussions on Drainage, that we have previously noted, of the old Philosophical Society. A careful examination of statistics shows that the death rate in the city for the year 1883-84, just before deep drainage was installed, was 20·4 per 1,000, and that for the two years since the deep drainage had been completed it was 17·6 per 1,000. And Dr. Whittell concludes his paper in these words:—"Meanwhile, we may fairly assume that the abatement of city nuisances, the speedy removal of filth from our premises, and the blessing of pure air, have produced the beneficial results we are entitled to expect from them, and that a large part of the remarkable reduction of mortality in Adelaide is due to the completion of our new system of drainage."

Between the years 1904 and 1907 a most important series of papers, seventeen in all, was communicated to the Society by W. H. Bragg, Elder Professor of Mathematics and Physics in the University of Adelaide, now Sir William Bragg, O.M., F.R.S., President of the Royal Institution of London. Bragg had previously contributed a paper in 1891 on the "Energy of the Electro-Magnetic Field," but in this series of papers he described the methods and results of the experiments in which he, with the later collaboration of Kleeman, Madsen, Dr. W. T. Cooke, and Glasson, first clearly established the specific character of the alpha rays emitted by radium and other radio-active elements in the process of disintegration. In particular he showed that each species of radio-active atom, if it emitted an alpha ray at all, ejected this particle with one and the same initial velocity and energy, so that the rays from this element had, unlike other kinds of radiation, a definite range in air of a few inches at most, coming to an abrupt stop when their energy was exhausted by interaction with the atoms encountered on their path. These experiments furnished the basis of a new and valuable technique of investigation into problems of radio-activity and threw much new light on the nature of the obscure process of radio-active disintegration. In his later papers Bragg turned his attention to other kinds of radiation, such as the beta and gamma rays from radio-active elements and X-rays. In regard to the latter he put forward an interesting speculation as to their nature, at that time unknown, and although this has not been confirmed by subsequent development, its fundamental concept, *viz.*, an elementary particle devoid of electric charge—now termed a "neutron"—has recently been shown to have a real existence and to be an important constituent of all atomic nuclei. In this early work on X-rays we may see the basis of the subsequent great work of Bragg's life, for which he, jointly with his son (Professor W. L. Bragg, of Manchester), received the award of the Nobel Prize in Physics, *viz.*, the application of X-rays to the experimental analysis of the structure of crystals. This series of papers represents a most fundamental and important contribution to the physical science of the day and, apart from any feeling of loyalty to the Royal Society of South Australia that there may have been with a South Australian research worker, these papers were sent to the Society mainly because in that way prompt publication could be secured in comparison with that obtainable by sending the papers overseas. That is an advantage that may still hold good under similar circumstances.

Of other papers on Physics, one by Prof. Kerr Grant and Mr. G. E. M. Jauncey, in 1912, demonstrated that ionisation is a general consequence of the collision of solid bodies in air, and Messrs. R. C. Mitton and E. G. H. Gibson contributed papers dealing with research work phenomena of surface tension.

About half of the papers of the kind under review, in the published Proceedings of the Society deal with subjects in the domain of Chemistry. Of these the majority apply the principles of inorganic chemistry to investigate the rocks and minerals, the waters and sands of South Australia. In the seventies the late Mr. J. T. Cloud, Metallurgist of the Wallaroo Smelting Works, called attention to the occurrence of various rare minerals. Professor E. H. Rennie, in 1887, made a chemical examination of the so-called rubies of the Macdonald Ranges and found that in all cases they proved to consist of silicates of alumina and iron, with small quantities of oxide of manganese, lime and magnesia, and hence were undoubtedly garnets. Mr. G. A. Goyder, at that time in charge of the Government Assay Department, investigated the composition of new minerals which he named *Stibiotantalite* and *Sulvanite*. Mr. A. J. Higgins dealt with tellurides from Wortupa in 1899. Our radio-active ores have been examined from the chemical standpoint by Messrs. Radcliffe, Prof. Rennie, Dr. Cooke and Mr. A. C. Broughton. Mr. R. G. Thomas discussed the gem sands of Encounter Bay in 1922, and Mr. A. R. Alderman the "Vanadium Content of Certain Titaniferous

Ores" in 1925. Dr. W. T. Cooke made a chemical examination of Davidite from Olary in 1916, showing that it gave off helium in quantity when heated to a red heat, 100 grammes yielding 15 c.c. of helium, and he completes the list with two papers recording chemical investigations into the nature of the brown coal at Noarlunga, published in 1932 and 1934.

In the field of organic chemistry, Professor E. H. Rennie devoted his spare time for many years to the examination of natural products of South Australian plants, and in particular he investigated the colouring matters of the insectivorous plant *Drosera Whittakeri,* which occurs abundantly in our hills. The colouring matters he thought to be *hydroxy-methyl naphthaquinone,* a conclusion which has since been confirmed, and colouring matters of similar composition have been found in more recent years in Bacillus Tuberculosis and in the green husk of the walnut. He contributed a paper on this subject in 1887. Since then other papers on natural plant products, especially essential oils, have been contributed by Messrs. H. H. Finlayson and P. A. Berry.

There are one or two other chemical papers of a more general and less local character, such as one on the "Toning of Photographic Silver Images," but by far the greater majority of the papers involving chemical investigation that have been contributed to the Society have dealt with the composition of materials, whether organic or inorganic, found in South Australia, and have been in the nature of a careful examination of the natural products of the country in which we live. They have thus been particularly appropriate to the Royal Society of South Australia. Apparently our chemists have sent their contributions to knowledge of a more general character to the Chemical Societies of Great Britain and have given to this Society chiefly the result of work on local products.

Apart from Chemistry and Physics, there are a few odd papers which may best perhaps be classified under Astronomy and Engineering. The astronomical papers begin with a discussion by Mr. C. Todd of the comet of February, 1880. Then follow papers on "The Variations of the Compass in South Australia," "Weather Forecasting in South Australia," "Observations on Jupiter," and finally a paper on "Circum-elongation Observations for Azimath," in which formulae are deduced for the reduction of a number of observations made on a circum-polar star near its elongation with the object of getting an accurate measure of the direction of the true meridian. These are of so varied a character that one can hardly discuss them, but obviously two of them at least are essentially South Australian. As associated with Engineering we might class two papers by Mr. G. Goyder, dealing with the "Cyanide Process for Gold Extraction," a paper dealing with the results of physical tests of South Australian timbers, another one on British Standards, and two dealing with the theory of columns and beams.

It is hardly to be expected that there will be any change in the tendency for papers, conveying the results of investigations made in this State into subjects dealt with in this review, to be diverted from the Transactions of the Royal Society of South Australia to periodicals and records of the more specialized big societies where they will be brought more directly under the notice of those specially interested in the subject considered. But there are many phases of these subjects which have a direct bearing upon South Australian problems, research upon which would be fittingly recorded in our Transactions. We cannot separate the different branches of Science into water-tight compartments. Many of the most difficult problems in Geology, Botany and Zoology depend for their solution upon the collaboration of the physicist and the chemist, and many of the special problems presented by these subjects in this State must probably be solved in the same way. The papers on Chemistry that are preserved in our records are for the most part fitting illustrations of the application of that science to the furthering of a knowledge of the products of our own State, but they are by no means the only contribu-

tions that involve the use of chemical analysis, which enters into many of the papers presented, especially those on Geology and Mineralogy. But Physics and Mechanics may be also very essential to the progress of knowledge of our environment. Such matters as climate, magnetic surveys, investigations into the strength and physical properties of our timbers and of our building stones, tidal and other natural physical phenomena, gravity, geodetic and geo-physical surveys, the flow of underground water, and many others obviously require the mathematical application of the principles of Physics and Mechanics. It is to be hoped, therefore, that the present policy of the Society of encouraging the contribution of such papers will be continued, because the Royal Society of South Australia seems to be the most fitting repository for all work advancing our knowledge of the State and its resources, and to make this knowledge complete it must be viewed from every aspect.

# CENTENARY ADDRESS-NO. 4.
# ONE HUNDRED YEARS OF SYSTEMATIC BOTANY IN SOUTH AUSTRALIA.

BY *J. M. BLACK, A.L.S.*

**Summary**

Although this paper deals with systematic botany in South Australia during the last 100 years, it would be impossible to ignore entirely the initial point in the collection and description of our plants-the visit of the celebrated botanist, Robert Brown, in Captain Flinders' ship, the "Investigator," in the year 1802. This voyage meant not only the discovery and survey of almost the whole coastal area of our State, but also the discovery of its flora. Brown began his work at Fowler's Bay and ended it near Mount Gambler. The result of his collection during a voyage round the greater part of the Australian coast was published in London in 1810 in a work, which established his fame.

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Although this paper deals with systematic botany in South Australia during the last 100 years, it would be impossible to ignore entirely the initial point in the collection and description of our plants—the visit of the celebrated botanist, Robert Brown, in Captain Flinders' ship, the "Investigator," in the year 1802. This voyage meant not only the discovery and survey of almost the whole coastal area of our State, but also the discovery of its flora. Brown began his work at Fowler's Bay and ended it near Mount Gambier. The result of his collection during a voyage round the greater part of the Australian coast was published in London in 1810 in a work which established his fame.

After the proclamation of the Province of South Australia in 1836, the first expedition on which botanical specimens were successfully collected was that of Captain Sturt in South and Central Australia in the years 1844 to 1846. From this arduous journey the great explorer brought back about 100 plant specimens, which were dealt with in a botanical appendix from the pen of Robert Brown. Previous to this date Eyre made a collection of plants during his daring overland journey along the Great Bight to King George's Sound in 1840-41, but they were lost in transit to Adelaide.

In 1847 Dr. Ferdinand Mueller (later Baron Sir Ferdinand von Mueller) landed in South Australia and at once began collecting in various parts of the State. His first paper on our flora was published in Hooker's Journal of Botany in 1852. Subsequently, with his headquarters in Melbourne, he became the acknowledged leader in botanical science throughout Australia, identifying numbers of plants collected by himself and other explorers during the latter half of the nineteenth century and describing many new species. Among the collections with which he dealt, and which are of special interest to South Australians, may be mentioned those of David Hergolt in the country west of Port Augusta (Babbage's expedition of 1858), of J. McDouall Stuart in the same districts during 1858-59, of Ernest Giles and his assistant (W. H. Tietkens) in the country near Ooldea and in the Musgrave Ranges in 1875 and 1876, of Sir John Forrest in his journey from Perth to Adelaide in 1870, and of William C. Gosse (later Deputy Surveyor-General of South Australia) in that part of Central Australia which lies immediately north of our border during 1873.

Among the local collectors who have done excellent work should be mentioned Dr. Hermann Behr, whose plants, collected near Gawler about the middle of last century, were described by Schlechtendal in the twentieth volume of Linnaea (1847); Carl Wilhelmi in the Port Lincoln district from 1851 to 1854, and the Rev. J. E. Tenison Woods in our Tatiara district. J. G. O. Tepper, an active member of this Society, contributed several papers to our Transactions on the flora of Yorke Peninsula and of the Adelaide plains and hills.

One of the finest collections of South Australian and Western Australian plants was that of R. Helms, who acted as collector of Lindsay's Expedition in 1891-92, the expenses of which were defrayed by Sir Thomas Elder. The botanical results were published by Mueller and Tate in our Transactions of 1896. Helms's specimens were distributed between the University Herbarium of Adelaide and the National Herbarium of Melbourne, and have been re-studied by many subsequent botanists, Australian, English and German.

The safety and effectiveness of exploring expeditions, and incidentally their ability to collect botanical treasures, was greatly increased by the substitution of camels for horses in sandhills and desert country. Tested experimentally by John McKinley during his journey to Cooper's Creek in 1861 for the relief of the Burke and Wills expedition, the use of camels became general on most of the great traverses in the seventies and in subsequent years. The Elder Expedition of 1891 had 44 camels, 10 riding and 34 pack animals.

Professor Ralph Tate published in 1890 his Handbook of the Flora of Extra-tropical South Australia and divided the State, for botanical purposes, into two regions—the Eremian, or dry and desert lands of the North, and the Euronotian, comprising the districts with better rainfall, from about the latitude of Port Augusta to Mount Gambier. He was the botanist, as well as the geologist, of the Burke and Wills Expedition, the use of camels became general on most of the numerous botanical papers to the Transactions of this Society, among them the first florula of Kangaroo Island. He was active in founding the Field Naturalists' Section of the Society and became its first chairman.

During recent years several of our members have distinguished themselves as diligent plant collectors in our Far North and in Central Australia, among whom should be mentioned Professor J. B. Cleland, H. H. Finlayson and N. B. Tindale. Professor Cleland has published several florulas of districts extending from Kangaroo Island to the Far North, as well as his Handbook of the Toad-stools and Mushrooms of South Australia. Mr. E. H. Ising has made extensive collections in the Ooldea districts, the Nullarbor Plain, the Far North and Central Australia, and has published four papers in our Transactions dealing with his discoveries. The author of the present address produced the Naturalised Flora of South Australia in 1909 and the Flora of South Australia between 1922 and 1929, besides a series of botanical papers appearing in our Transactions since 1909. Our orchids have always been in the able hands of Dr. R. S. Rogers, who described all our local species in the Flora of South Australia. Professor J. G. Wood published in our Transactions of 1930 an exhaustive paper on the Vegetation of Kangaroo Island and the adjacent peninsula.[1]

Many distinguished botanists outside South Australia have assisted in the elucidation of our flora during the present century. Foremost among these stands J. H. Maiden with his revision of the Eucalypts, an illustrated work continued after the death of the great Sydney botanist by his assistant, W. F. Blakely, who in 1934 published his valuable Key to the Eucalypts, with shorter descriptions of all the species. The genus *Pultenaea* was revised by the Victorian botanist, H. B. Williamson,, and a similar service was performed for *Bassia* by R. H. Anderson, of the Sydney National Herbarium. The experts of the Royal Botanic Gardens at Kew have done much for Australian systematic botany by the publication in recent years of the following revisions:—*Lilaeopsis* by Sir Arthur Hill, the *Panicum* of Bentham's Flora and *Stipa* by Miss D. K. Hughes, *Frankenia* by V. S. Summerhayes, *Dentella* by H. K. Airy-Shaw, and several genera of Australian grasses by C. E. Hubbard. Dr. K. Domin, of Prague, who travelled widely in Queensland, has published, during the last 20 years, a series of papers revising a great portion of the Australian flora. Dr. J. Th. Henrard, of Leiden, has issued a monograph on the genus *Aristida*, throwing much new light on our Australian species. Dr. Wheeler, of the University of California, has quite recently done a great service to Australian taxonomy by

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(1) Among the noted systematic botanists not mentioned in this article is Mr. J. M. Black, A.L.S. Mr. Black has published "The Naturalized Flora of South Australia" (1909), and a 4-volume "Flora of South Australia" (1922-1929), together with a large number of botanical papers, of which "Additions to the Flora of South Australia, No. 34," is published in this volume of the Royal Society's Journal.—Ed.

her revision of our *Nicotianas,* based largely on living specimens of our tobaccos grown from seed.

One word as to the broad basis of systematic botany—the classification of families and genera. The arrangement of Linnaeus, which was based chiefly on the number of stamens and styles, was greatly improved by Jussieu, who, in 1779, was the first botanist to co-ordinate the genera of plants into families more or less as we know them today. His work was elaborated by De Candolle in 1818, and later in the century by Bentham and Hooker in their Genera Plantarum, and by Bentham in the Flora Australiensis. All these systems were based on the idea of the fixity of species. The first phylogenetic system proposed, subsequent to the general acceptance of the theory of descent, was that of Engler and Prantl, which was published about the end of last century and which has been followed by most botanists up to the present day. During the last ten years a Kew botanist, Mr. J. Hutchinson, has published two volumes making certain changes in Engler's classification, and doubtless the last word has not been written on this difficult subject. Hutchinson's system shows a tendency, in regard to the sequence of some of the larger groups, to revert to that of Bentham and Hooker. For instance, he places the Dicotyledons before the Monocotyledons on the ground that certain monocotyledonous families, such as the *Alismataceae* and *Scheuchzeriaceae* are closely allied to the *Ranunculaceae* or Buttercup Family, which he considers to be the most primitive of herbaceous Dicotyledons.

There have always existed among botanists two opposite tendencies with regard to the treatment of genera. Some prefer large comprehensive genera, divided into few or many sections, while others consider it better to treat each of these sections as a distinct genus. In botanical slang these two classes of botanists are termed "lumpers" and "splitters," and, of course, there are the same two diverse tendencies in regard to the treatment of some species. Of recent years the division of large and sometimes unwieldy genera has become very popular. Let me give one example. When the illustrious English botanist, George Bentham, wrote some 60 years ago that great and indispensable classic, the Flora Australiensis, he maintained *Panicum* as a comprehensive genus of grasses. When Miss Hughes, in 1923, revised Bentham's *Panicum,* she divided it into 14 different genera, following the example set by the great agrostologist, Dr. Stapf, in the Flora of Tropical Africa. Another grass genus, *Andropogon,* has also undergone considerable division. All this work leads to changes in nomenclature, puzzling at least for a time, the argument of the revisionists being that the final result will be additional clarity and an increase in scientific exactness.

During the last few years a plea has been voiced, chiefly in forestry circles, for the creation of a list of certain well-known specific names to be conserved, although they are not the earliest names given to the species in question. The list of generic names which it has been determined to conserve *(nomina generica conservanda)* is pointed to as an example which should be followed in regard to species. But the two cases are scarcely analogous. In 1891 a German botanist, Dr. O. Kuntze, published a revision of genera, in which the law of priority was rigorously applied. The result was chaotic—about 30,000 names of plants were changed. To overcome the confusion thus caused, the Botanical Congress of Vienna (1905) agreed upon a list of generic names to be conserved, and this list was extended by the Congresses of Brussels (1910) and of Cambridge (1930). But genera are comparatively few, while the number of species is enormous. The majority of systematic botanists has always been opposed to a system by which certain specific names would be arbitrarily conserved although they are not the earliest under which a description was published. The proposal for a list of specific names to be conserved was first raised and rejected at Cambridge, and at the Congress of Amsterdam (1935) the motion came to a division and

was defeated by 208 votes to 61. Subsequently it was decided "that an international committee be appointed to draw up a list of names of economic plants according to the international rules, and that this list may remain in use for a period of 10 years." The publication of this list will be awaited with much interest.

As two examples of the changes in specific names under the law of priority to which objection has been raised in Australia may be mentioned the substitution of *Eucalyptus gummifera* for *E. corymbosa* as the name of the Bloodwood of New South Wales and Queensland, and the change in the name of our well-known Redgum from *Eucalyptus rostrata* to *E. camaldulensis*. On the other hand, it may be noted that the name of the Remarkable or Monterey Pine, which has been extensively planted in Australia as a timber tree, has been altered from *Pinus insignis* to the earlier name of *P. radiata*, and that this change appears to have been accepted by foresters and dealers without any difficulty.

Turning now to the future, it may be said at once that there is plenty of work ahead for Australian botanists and collectors in searching our vast territory for new species and for further research in regard to species which are still imperfectly known. Even in the comparatively well investigated area of the Adelaide Plains and the Mount Lofty Range new species have been discovered in recent years, and other native plants previously only known from distant localities have been found to exist. There are also the introduced aliens, sometimes beneficial and sometimes mischievous, increasing in number with every year, to be studied and recorded. Among the cellular plants the larger fungi have been recently described by Professor Cleland in one of the science handbooks, but other forms, such as the seaweeds, mosses, liverworts and stoneworts have received little, if any, attention. In addition to this there are many important genera of our flowering plants still awaiting a revision by careful and enthusiastic botanists, whose researches will add notably to our present knowledge of a great flora.

# CENTENARY ADDRESS-NO. 5.
# ONE HUNDRED YEARS OF ENTOMOLOGY IN SOUTH AUSTRALIA

*BY J. DAVIDSON, D.SC.*

## Summary

At the time of the foundation of the Province of South Australia in 1836, several well-known naturalists in Europe were interested in collecting and describing insects. As a branch of natural history, however, insects were generally regarded with indifference. This may have been due to their abundance and relatively insignificant size compared with other animals.

With the appearance of the first volume of the classical work, "An Introduction to Entomology," by W. Kirby and W. Spence, in 1815, followed in 1839 by Westwood's "Introduction to the Modern Classification of Insects," an increasing interest in entomology developed in England. The Royal Entomological Society of London was founded in 1832.

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Waite Agricultural Research Institute, University of Adelaide.

At the time of the foundation of the Province of South Australia in 1836, several well-known naturalists in Europe were interested in collecting and describing insects. As a branch of natural history, however, insects were generally regarded with indifference. This may have been due to their abundance and relatively insignificant size compared with other animals.

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Owing to the abundance of insect life compared with other animals, it was inevitable that workers of this period would be engaged chiefly in recording, describing and classifying the different kinds of insects, according to the accepted binomial system of nomenclature. Entomology gradually developed along these lines, as a special branch of zoology, due largely to the enthusiasm of a number of amateur workers who devoted their leisure to the study of insects. It is perhaps difficult for us to appreciate now, that the conception of the cellular structure of animals was unknown until the work of Schwann about 1839.

Prior to the foundation of the Province, Francois Péron and C. A. Leseur, naturalists to Baudin's expedition, had collected insects on Kangaroo Island; some of these were described by Latreille of the Paris Museum, who became Professor in 1829 following the death of Lamarck.

In the early Transactions of the Entomological Society of London, the Rev. W. Hope described new species of insects collected at Adelaide by Mr. C. D. E. Fortnum, who appears to have resided in the colony during 1840 to 1845.

Charles Algernon Wilson, one of the original members of the Adelaide Philosophical Society, merits the title of being the first entomologist in South Australia. Wilson arrived here in 1839, and was an officer of the Supreme Court. A cousin of Alfred Russell Wallace, he had a naturalist's interest in insect life, and paid particular attention to insects which were troublesome to the colonists. From 1840 onwards Wilson contributed numerous articles on entomology to "The Register," and later to the "Garden and Field," under the pen name of "Naturae amator." In 1856 he read a paper to the Society entitled "Wood-eating Insects," which contained observations he had made on the collapse of a wooden bridge on the Adelaide main road, due to damage caused by boring beetles. Wilson also contributed observations on South Australian insects to the Transactions of the Entomological Society of London.

In 1867 F. G. Waterhouse, first Curator of the South Australian Museum, read a short paper on a parasite of the order "Strepsiptera," which had been collected near Gawler by Mrs. Kreusler; it is the first record of this interesting order for Australia.

Prior to 1878 there appears to have been little advance in our knowledge of the insect fauna of the State. In the anniversary address to the Society in that year, Professor Tate remarked upon the lack of interest shown in the natural history

of South Australia. This address apparently stimulated J. G. O. Tepper to communicate a paper to the Society in 1879, entitled "The Insects of South Australia: An Attempt at a Census." Tepper pointed out that Tate had stated that only 782 species of insects had been recorded from South Australia, whereas Tepper had 2,655 species represented in his collection; he had been collecting insects in the State for some 20 years. About 1883 Tepper became associated officially with the South Australian Museum. He communicated several papers on insects to the Society as well as observations on many exhibits; he added considerably to the insect collections of the Museum.

The Rev. T. Blackburn, a resident of Adelaide, began publishing on Australian Coleoptera in the Transactions for 1886-1887; from that date until his death in 1912 he regularly communicated papers to the Society; he also contributed papers to outside journals. An obituary notice of this distinguished Coleopterist states that his entomological publications reached a total of 3,696 pages, and that he described or named 3,069 species of Australian Coleoptera.

Arthur M. Lea, who came to Adelaide in 1911 as entomologist at the Museum, in succession to Tepper, had communicated a paper on Australian Coleoptera to the Society in 1879. After his arrival in Adelaide, Lea was a regular contributor to the Transactions on Australian beetles, until his death in 1932. An obituary notice states that Lea presented 43 papers to the Society, which occupied 2,378 pages in the Transactions; he described nearly 6,000 species, of which 2,329 were described as new. An enthusiastic collector, he greatly enriched the collection of insects of the Museum during his period of office.

Of other workers on Coleoptera, E. W. Ferguson, who died in 1927, communicated papers to the Society in 1914 and 1915; H. J. Carter contributed several papers to the Transactions during 1913 to 1919, and Albert H. Elston during 1919 to 1929.

In the order Lepidoptera, Edward Meyrick, a world famous authority of this order, collected in South Australia during 1882; he published a list of South Australian species in the Transactions for the following year. In 1890 he commenced a long series of papers on Australian Lepidoptera, which appeared in the Transactions at intervals until 1907.

Dr. Alfred Jefferis Turner, another authority of the Lepidoptera, began communicating papers on Australian species to the Society in 1894; his papers appeared in the Transactions at intervals until 1933.

Oswald B. Lower, a resident of Adelaide, worked particularly on the Lepidoptera of South Australia. A number of papers under his name appear in the Transactions during 1892 to 1923. Lower died in 1925.

Other contributors to the Transactions, on Lepidoptera, were C. A. Wilson (1865), W. H. Gaze (1881), M. E. Guest (1882-1887), and N. B. Tindale (1922-1923). Tepper refers to several collectors in the State, but they do not appear to have published their observations. These names include Bathurst, Behr, Odewahn, Jung and Waterhouse.

In the remaining orders of insects, our knowledge of the South Australian fauna is small. Tepper was interested in all the orders, but gave particular attention to the Orthoptera; in recent years N. B. Tindale has dealt with certain of the families. H. Womersley, who succeeded Lea in 1932 as entomologist at the South Australian Museum, has contributed papers dealing with the apterygota of Australia; in 1932 he established species of the order Protura, for Australia, on specimens collected by D. C. Swan. In the Hymenoptera there are five papers in the Transactions by A. P. Dodd, one by A A. Girault, and two by W. M. Wheeler. It is interesting to recall that the "honey pot ant," *Camponotus inflatus*, was described by Sir John Lubbock in the Journ. Linn. Soc. London, from specimens sent from Adelaide in 1880. Specimens taken at Barrow's Creek were exhibited

at a meeting of the Society in November of that year; this appears to be the first record for Australia, and it was stated at the meeting that only one other species of "honey pot ant" was known (from Mexico).

In the Hemiptera there are two small papers by W. M. Maskell on Coccidae, and one by J. H. Ashton on the cicadas in the South Australian Museum. During recent years W. H. Hale has contributed studies on aquatic Hemiptera; J. W. Evans, two papers on the Eurymelinae and Ipoinae; R. J. Tillyard, two small papers on wing venation and new species of "stone flies." In the Presidential address to the Society in 1895, Professor Tate was able to show that 1,559 new species of insects had been described in the Transactions.

During the nineteenth century there was a marked development of agriculture in Europe and North America. Associated with this development was a definite realization of the damage to forest trees, crops and stored products, caused by the activities of insects. Moreover, about the end of the century, it was demonstrated that certain insects were vectors of particular diseases of man and domestic animals. Beijerinck had discovered the presence of virus diseases in plants in 1889. These developments created a demand for specific information about economic species, which resulted in the appointment of official entomologists in several countries, whose duties were to study injurious insects and recommend measures for their control. In his address to the Society in 1878 Professor Tate referred to the increasing importance of entomology in this respect. In the Annual Report of the Society for 1885-1886, it is stated that the Council had made a recommendation to the Board of Governors of the Museum with regard to the formation of a collection illustrative of economic entomology in the State.

Here we have the beginnings in South Australia of what is now widely known as "Economic Entomology." The term is a useful one, since it fixes the attention on the practical aims. Research on injurious insects, however, embraces studies in all departments of entomology. The real objective is to establish exact knowledge which may be employed in the control of insects. This aspect of entomology is referred to in Europe as "applied entomology." The development of all branches of entomology during the past half century is closely bound up with the history of applied entomology.

Locusts and other insects affected the crops of the early settlers. Fortunately, insects were not troublesome as vectors of disease to man or to his domestic animals. The numerous articles on injurious insects written by C. A. Wilson in "The Register" and "Garden and Field" show that there was a demand for this kind of information.

In 1870 Mr. T. S. Reed read a paper before the Society entitled "The Importance of Silk Culture as a Branch of Colonial Industry." Successful attempts to cultivate silkworms had been made in New South Wales, and the paper discussed the possibilities of doing so in South Australia. In the following year Dr. Schomburgk gave a paper on "The Causes of the Disease of Silkworms"; the paper dealt particularly with the disease of the caterpillars, which swept throughout silk-producing countries about 1853.

In April, 1882, C. A. Wilson presented at a meeting of the Society a copy of the important French publication on *Phylloxera* of the vine, by Maxime Cornu. This subject was of importance to vignerons, owing to the severe losses in vineyards caused by this pest in Europe, and its discovery in Australia some time in the 1870's.

The Agricultural Bureau was formed in 1888. About this time Mr. Frazer Crawford, a photolithographer in the Surveyor-General's office, was widely known in the State for his interest in economic insects. Crawford was elected a Fellow of the Society in 1865; but his interests in entomology lay more with the habits of injurious insects. In 1886 Crawford had reported on the apple pests of the

State, and in 1890 he presented a report to the Agricultural Bureau dealing with the insect and fungus pests of the State. He was an inspector under the Vine, Fruit and Vegetable Protection Act.

Crawford's name will live in the history of applied entomology for the part he played in the successful introduction into California, in 1889, of the ladybird, *Novius cardinalis.* At that time the citrus-growing industry in California was threatened owing to the cottony cushion scale *(Icerya purchasi)* pest, a species which arrived there from the Australasian region. Crawford discovered a parasite fly *(Lestophonus)* attacking this scale insect near Adelaide. As a direct result of this, the United States Department of Agriculture sent A. Koebele to investigate the position. Koebele arrived in Adelaide in October, 1889, and together with Crawford and Tepper, visited a garden in North Adelaide where the ladybird, *Novius cardinalis,* was found feeding on the scale insect. Some of these beetles were sent to California, the first consignment being collected at Mannum. The predator multiplied rapidly in California, and within six months they had controlled the scale insect. When Crawford died in 1890, the Department of Agriculture of the U.S.A. paid a tribute to his help in this classical example of successful biological control.

This striking success stimulated greater interest in applied entomology in Australia. Within the next few years government entomologists were appointed to the Departments of Agriculture in the various States. In South Australia the official entomologist at the South Australian Museum determined specimens for the Department of Agriculture, and gave information and advice on injurious insects. This service appears to have been adequate for the requirements of the department, since a definite post as government entomologist was not created in this State.

In 1894 Geo. Quinn became associated with the horticultural branch of the Department of Agriculture. He published observations on various economic insects of the State in the "Journal of the Department of Agriculture," which made its first appearance in 1897. Some years later a service of agricultural and horticultural instructors was established. These officers advise the farmer and orchardist on matters relating to the control of insect pests.

In 1924, and again in 1926, the woolly apple aphis parasite *(Aphelinus mali)* was introduced into South Australia from New Zealand by Mr. Quinn. This parasite became established in the apple-growing districts and now exerts a partial control over the aphis.

In 1923 T. Harvey Johnston communicated a paper to the Society dealing with the blowfly problem in Australia.

In 1929 a Department of Entomology was established at the Waite Agricultural Research Institute, of the University of Adelaide. Courses in entomology are given to degree students, and research is carried out on various entomological problems. In addition, an advisory service to the Department of Agriculture is provided on entomological matters. Since its inception in 1929 certain insect problems of pastures, cereals, orchard and market garden crops have been investigated. In addition, experimental work on the effect of climate and weather on insect abundance, including systematic field observations, has been carried on, with a view to obtaining more definite information relating to the ecology of insects in Australia.

We have seen that the entomological papers communicated to the Society have been mainly concerned with the description and classification of insects. Very little attention has been given to their structure and habits. In 1922 O. W. Tiegs communicated a comprehensive paper dealing with the structure and post-embryonic development of the Pteromalid wasp, *"Nasonia,"* and the physiology of insect metamorphosis. During recent years papers relating to the ecology

of insects, particularly with reference to the influence of climate, have appeared in the Transactions.

With the commencement of the annual publication of the Records of the South Australian Museum in 1918, certain entomological papers by the Museum staff are now placed in that Journal. A few papers dealing with experimental work on insects have been published in recent years in the "Australian Journal of Experimental Biology and Medical Science," an Adelaide University publication.

Although few papers dealing with the applied aspect of entomology have been published in the Transactions, the Society appears to have been kept informed of such matters affecting the State through the varied exhibits presented at its meetings. Certain of the exhibits are of interest in relation to the spread of particular insects. In 1903 Tepper exhibited specimens of "Chermes," an aphis pest on *Pinus halepensis;* this insect was doubtless *Pineus pini,* a European species now commonly occurring on *Pinus radiata.* At the May meeting in 1915, Lea exhibited living pupae of Macleay's orange butterfly *(Papilio anactus),* taken on citrus at Berri; this was the first record for South Australia. The species is now frequently seen in summer on the Adelaide plains, presumably having made its way down the Murray from New South Wales.

One of the important aims of natural history in a new country is that of placing on record the fauna and flora of the country. Therefore, considering the wealth of insect forms, the descriptive character of the earlier papers presented to the Society is understandable. Amateur enthusiasts have assisted greatly in the collection and recording of the insect fauna in many countries. The workers have been relatively few in South Australia and many groups of our insects remain unexplored.

There are many difficulties associated with a practical and rational system of classification of insects. Many of the earlier papers in the Transactions may appear to be a monotonous descriptive catalogue of a collection of inanimate objects. Taxonomy, however, is a useful and practical method of arranging insects. It is a valuable aid in the study of other branches of entomology; but it cannot be considered as an end in itself. Post-Darwinian developments in biology, particularly in genetics, show that the modern concept of a species embodies much more than a consideration of its external characters.

A species has been defined as a community of individuals having distinctive morphological features and habits which separate them from related communities; they are fertile within themselves. In the absence of knowledge about habits and biology, errors in classification may readily arise: we are familiar, for instance, with examples of seasonal variation and sexual demorphism. The effect of environment on external characters in insects is often difficult to assess; in general, insects are plastic and adaptable, and the range of variation may be large. Variations due to discontinuous mutations, and the problem of convergence, all add to the difficulties of establishing the correct placing and phylogenetic relationship of many "species." There is also the question of physiological races.

In order that systematic studies may be carried out efficiently today, the worker must have access to adequate collections and complete literature on the subject. The South Australian Museum has one of the richest collections of insects in Australia; it includes a large number of types. The value of the collection will be increased when the various groups have been worked out by specialists. The publication of comprehensive revisions of particular groups of insects might well be considered as an important function of a natural history museum. Research of this kind would be helpful to workers engaged more in the applied branches of entomology. Biological surveys, and the grouping of insects of the State according to their habits and environment, would enable us to understand more clearly the inter-relationship of insects in an ecological sense.

An accurate record of the parasites and predators of our insects would be a valuable contribution to South Australian entomology.

During the past 20 years or so our knowledge of the biology of insects has been advanced considerably; this is largely due to the demand for exact information about species of economic importance. There has been a big development of experimental work relating to the physiology of particular insects and their reactions to changes in the temperature and moisture in their physical environment. Attempts are being made to understand the precise conditions in the physical and biotic environment which cause irregular fluctuations in insect numbers and lead to insect plagues. Investigations at the Waite Institute include experimental work relating to the effect of temperature, moisture and food on the seasonal occurrence and rate of multiplication of several species of insects of economic importance in South Australia. A knowledge of the exact conditions in the physical environment of these species, in relation to the influence of climate and weather, is an important consideration in this respect. A knowledge of the influence of competition for food, and the effect of parasites and predators is equally important.

For research in these branches of entomology more extensive equipment and laboratory facilities are required than is the case with studies in taxonomy and the natural history of insects. However, our knowledge of the insect fauna of South Australia, from the aspect of taxonomy and natural history, is still very far from complete. The amateur naturalist, who is interested in insects as a hobby, can do much to extend this knowledge if he has the equipment of enthusiasm and accurate powers of observation. It was these qualities which appear to have been mainly responsible for the outstanding contributions of Charles Darwin to Biology, and of Henri Fabre to Entomology.

# CENTENARY ADDRESS-NO. 6.
# A HUNDRED YEARS OF ZOOLOGY IN SOUTH AUSTRALIA.

*BY PROFESSOR T. HARVEY JOHNSTON*

**Summary**

It has been a difficult task to select a suitable title for this address, which forms one of the series intended to represent our Society's contribution to the celebration of the Centenary of the State of South Australia. An attempt to survey the growth of our knowledge of the local zoology during the past century would have been too ambitious; would have necessitated far too great an amount of research; and would have been far too lengthy for the time allotted and the printing space allowed for similar addresses. It has been deemed more satisfactory to adopt the above title, as it permits one to take into account zoological work published in South Australia, whether it relates to our State or not. Excepting early references to our zoology, it excludes work relating to our fauna published elsewhere. It thus indicates more particularly what part the local organizations have played in the publication of scientific information concerning the chosen subject; and it indicates especially the important part played by our Royal Society in such work. The address is, then, largely concerned with the zoological activities of our Society and of its parent, the Adelaide Philosophical Society. It also takes into account the work of the various organisations which have directly or indirectly arisen from it-such as the Field Naturalists' Section, the South Australian Museum, and the Ornithological Society.

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# A HUNDRED YEARS OF ZOOLOGY IN SOUTH AUSTRALIA.

By Professor T. Harvey Johnston, University of Adelaide.

It has been a difficult task to select a suitable title for this address, which forms one of the series intended to represent our Society's contribution to the celebration of the Centenary of the State of South Australia. An attempt to survey the growth of our knowledge of the local zoology during the past century would have been too ambitious; would have necessitated far too great an amount of research; and would have been far too lengthy for the time allotted and the printing space allowed for similar addresses. It has been deemed more satisfactory to adopt the above title, as it permits one to take into account zoological work published in South Australia, whether it relates to our State or not. Excepting early references to our zoology, it excludes work relating to our fauna published elsewhere. It thus indicates more particularly what part the local organisations have played in the publication of scientific information concerning the chosen subject; and it indicates especially the important part played by our Royal Society in such work. The address is, then, largely concerned with the zoological activities of our Society and of its parent, the Adelaide Philosophical Society. It also takes into account the work of the various organisations which have directly or indirectly arisen from it—such as the Field Naturalists' Section, the South Australian Museum, and the Ornithological Society.

The title is not quite correct, because by arrangement with the Council of the Society, entomology has been excluded almost entirely and has already been dealt with by a fellow-member. Anthropology has been excluded for a similar reason, but animal (including human) physiology has been included, though only very brief notice is given to this important portion of experimental zoology. It has been difficult to draw the line when one has attempted to review the activities of such a publication as the Australian Journal of Experimental Biology and Medical Science, since Physiology, Serology, Pathology, and some aspects of Biochemistry and Bacteriology may be interrelated. Palaeontology has been taken into account in the case of Tertiary and Post-tertiary forms, which are chiefly molluscs, brachiopods, polyzoa, echinoids, corals, and foraminifera. The papers relating to marsupials found in Post-tertiary deposits are mentioned.

Various short references and identifications of zoological interest, by Tate and others, contained in the earlier volumes of our Transactions, are not considered in this address, nor are records and notes contained in the Abstract of Proceedings of the various meetings of our Society.

Though the State's history did not begin until late in 1836, some of its zoology was then already known, and brief references may now be made to some of these early records. Flinders discovered Kangaroo Island in March 1802, and in his account, "Voyage to Terra Australis," published in 1814, he referred to the abundance of kangaroos, some of which furnished fresh meat for his men, and on that account he gave the island its present name. This animal is usually regarded as *Macropus* (or *Thylogale*) *eugenii*, which Desmarest described, in 1817, from a specimen taken on St. Peter Island, Nuyt's Archipelago. Wood Jones, though accepting and applying the name, thought the specific identity of the wallabies from these two isolated insular localities, to be unlikely. Flinders, in 1802, collected on Flinders Island, Investigator Group, specimens of a very small wallaby, regarded by Wood Jones in 1924 as a distinct form, *Thylogale*

*flindersi.* He reported the presence at one or more of the localities visited by him—Fowler's Bay, St. Peter Island (Nuyt's Archipelago), Denial Bay, Thistle Island, Port Lincoln district, Gulf St. Vincent, and Kangaroo Island—of the following animals:—teal and other ducks, kangaroos, seals, emu or cassowary, pelicans, pied shags, sea-eagle, gulls, sea pie (? *Daption),* snakes, rays, oysters and winged freshwater insects. He recorded seeing the tracks of dogs (dingo, probably) and of the emu or cassowary on the mainland (Fowler's Bay). The extraordinary tameness of kangaroos and seals on Kangaroo Island was regarded as evidence that it was uninhabited by man. He published an illustration of a beach on the island near Kangaroo Head, showing seals of two different sizes, several wallabies or kangaroos, and two emus.

Very soon after Flinders' visit to these regions, which subsequently became part of the colony of South Australia, Baudin, with the French ships "Geographe" and "Naturaliste," arrived at Kangaroo Island (which he renamed Ile Decrès) in April, 1802; and again in January, 1803. Accompanying him as zoologist was Peron, who made extensive collections during a month's sojourn there, and wrote an account of his experiences in his "Voyage de Decouvertes aux Terres Australes," vol. ii (1816). Peron reported the occurrence on Kangaroo Island of parrakeets, cockatoos, titmouse (with a collar of ultramarine blue), fly-catchers, bullfinch (with red tail feathers), thrushes, golden-winged pigeons, owl, white vulture, yellow-throated pelicans with black and white wings, terns, oyster catchers, sea eagle, teal, *Procellaria* spp., and great flocks of emus. He referred to the presence of two kinds of kangaroos, *Dasyurus,* hair and fur seals *(Otaria),* and various lizards, and stated that Kangaroo Island had enriched his collection by 336 different species of crustacea, spiders, *Julus,* centipedes, insects, worms and zoophytes; there being 54 new species of insects in 33 different genera, 26 species of sponges, two of scorpions, etc. Some of these organisms were designated generically. *Pinna,* the oyster, and *Haliotis* were also mentioned. Fish were referred to and included *Labrus, Scomber, Scombresox, Coryphaena,* barracouta, trumpet fish, *Balistes,* etc.; and he mentioned the abundance of a large species of shark, 15 to 20 feet in length, in Nepean Bay, where it probably fed on seals. The collection was studied by various investigators, amongst whom were Latreille (1817, insects), Dumeril and Bibron (reptiles) and Lamarck (1818, molluscs). Mr. B. Cotton has shown me a specimen of a chiton, *Ischnochiton lineolatus* (Blainv.), now the property of the South Australian Museum, bearing in Peron's handwriting the locality "Ile King," this shell being actually on board when Baudin and Flinders (accompanied by the celebrated botanist, Robert Brown) met on the French vessel, "Le Geographe," in Encounter Bay, April 8, 1802. This interesting and historic specimen was obtained through the kind offices of Mons. Dupuis (formerly Conchologist at the Brussels Museum) and of Mr. E. Ashby, one of our members.

Peron recorded seeing numerous emus ("casoars") and published an illustration showing a group of them. Baudin named a locality near Cape Borda, Ravine de Casoars. Three living specimens of this small emu were taken to France and, ultimately, two reached the Paris Museum, while the third, according to Giglioli ("Nature," May 31, 1900), is now in the Zoological Museum in Florence. The species, which soon became extinct through the activities of the sealers and their aboriginal consorts some years prior to the official settlement of the island in 1836 (according to Moore in 1924), was regarded as *Dromaeus ater* Vieillot. But this term was really a renaming of *D. novaehollandiae,* the larger form inhabiting the mainland; consequently, Rothschild in 1907 designated it *D. peroni,* and separated it specifically from the small emus (also now extinct) which occurred on King Island *(D. minor* Spencer, or *D. spenceri* Mathews) and in Tasmania *(D.*

*diemensis* LeSouef). The literature regarding the Kangaroo Island emu was summarised by Howchin in 1926. Mathews, in 1912, suggested that *D. peroni* was generically distinct from the mainland form and erected *Peronista* to receive it. It is represented in Australian collections by skeletal fragments taken mainly from caves.

An American whaling vessel visited Kangaroo Island in 1803, and a few sealers and escaped convicts took up their abode there soon afterwards, and supplied salt, seal skins and kangaroo skins to small ships from Sydney and elsewhere, which called there occasionally for cargo and fresh water. Captain Dillon, in 1832, reported that he had visited Kangaroo Island in 1815, and had taken away a cargo of seal skins, 500 from the island and 100 from Althorpe Island; he also recorded the presence of abundance of kangaroos, emus and porcupines *(i.e., Echidna)*. Captain G. Sutherland gave a brief report on his stay of about seven months in the island in 1819, and mentioned the presence of abundant kangaroos and emus, hair and fur seals, whales, porcupines, parrots, wild pigeons, black swans, ducks, snakes, guanas (apparently *Varanus)*, snapper, sharks, and oysters; but his report was not published till 1831. Captain Goold was there in 1827 for seals and recorded the presence of kangaroos and turtles resembling hawksbills. Wootton visited the island in 1823 and referred to the kangaroos. Though sealing played an important part in the early history of the island, a critical examination of our seals was not undertaken until 1925, when Wood Jones endeavoured to remove the confusion associated with their identification. Whaling operations were carried on in the vicinity of Kangaroo Island by Pemberton as early as 1803. Hudson (1832) recorded seeing numerous whales there and mentioned that 160 were observed in one day in Encounter Bay—chiefly the black whale *(i.e., Balaena australis)*, but the sperm whale was also represented. Hamborg visited Port Lincoln in May, 1832, and reported that whaling had been in operation during the preceding three seasons *(i.e.,* 1829-31) and that the black whale was common, but that sperm whales were rarely met with. He referred to the abundance of seals and fish, mentioning amongst the latter, grey mullet, red mullet, soles, mackerel, herrings, snapper, jewfish, salmon, trumpeters, parrot fish, rock cod, and sting-ray; in addition to turtles, oysters, mussels and cockles. Hart visited Kangaroo Island in 1831, and obtained 150 seal skins and 12,000 wallaby skins from the islanders.

Sturt, in volume 2 of his work, "Two Expeditions into the Interior of Southern Australia during 1828, 1831," etc., published in 1833, referred to the abundance of swans, pelicans, ducks and geese (p. 171), as well as cockles (p. 170) in the Encounter Bay district, and also to a kind of salmon entering Lake Alexandrina, apparently from the sea (p. 236). In an Appendix, he gave a list of fossils (molluscs, echinoids and polyzoa) from the Murray cliffs. In an Appendix to his later work, "Narrative of an Expedition into Central Australia, 1844-5-6" (vol. 2, 1849), he published a list of the "animals and birds of Central Australia," and referred to fossils, fish, etc.

In the "Hobart Town Gazette," of June 12, 1826, there is an article on "Kangaroo Island and the Runaways *(i.e.,* escaped convicts) in the Straits," in which reference is made to kangaroos, seals and sealing, cockatoos, etc. This short account was republished by T. Gill in 1909, together with a letter dated September 14, 1836, from one of the earliest of the new settlers on Kangaroo Island, also referring to sealers and sealing. Fisher visited the island in 1836 and mentioned seeing parrots, black cockatoos, gulls, black snake, and periwinkles.

This State was founded as a British Province in 1836, and whaling stations were established in Encounter Bay (1837), Sleaford Bay (1839), Thistle Island (1839), and Hog Bay (1841). The difficulty of indicating a locality for many

of the earlier-described South Australian animals is due to the former use of the term "New Holland" for the eastern half of Australia, and of "South Australia" for any locality along the southern coast of the continent. Then again, because the Northern Territory was for so long a part of South Australia, and its main collections were lodged in the Museum in Adelaide, some specimens from the north of Australia came to be indicated as having been collected in South Australia.

W. H. Leigh, in "Reconnoitering Voyages and Travels in South Australia" (London, 1840), mentioned various forms of animal life met with in Kangaroo Island during his visit in 1837—opossum, kangaroo, wallaby, Norway rat (which had overrun the island), birds (including mutton birds), guano (= goanna—his account suggesting *Varanus* sp), snakes, ants, blowflies, spider, scorpion, crayfish and oysters. T. H. James, in "Six Months in South Australia" (London, 1838), mentioned seeing "sooty petrels" and "barnacle geese" at Petrel Bay, near St. Francis Island, and stated that Port Lincoln was a resort for black whales during June, July and August.

Capper, in 1838 and 1839, referred to many forms of animal life, mentioning the native dog, five kinds of kangaroos, two or three kinds of flying squirrel, two opossums, bandicoot, emu, black swan, two or three kinds of ducks, several pigeons, snipes, plovers, quails, wild turkey, parrots, cockatoos; also fish such as snappers, bream, mullet, whiting; rock and bed oysters, and prawns. Whales were abundant. Various arthropods were also mentioned—scorpions, centipedes, tarantulas, flies (stated to be very troublesome and abundant), mosquitoes and locusts.

W. H. Selway, one of the oldest members, in his jubilee address to the Field Naturalists' Section of our Society, drew attention to the following item of interest. J. Blacket, in his "History of South Australia," stated that in December, 1838, there was formed, in Adelaide, the Natural History Society of South Australia, the chief worker being an entomologist, C. A. Wilson, who contributed under the pen-name of "Naturae amator" weekly notes on natural history subjects to the "South Australian Register."

Dr. Litchfield gave a lecture on the natural history of South Australia, and this appeared in the local Press in 1839, being republished in London in 1840. He referred to the outstanding characters of marsupials and mentioned the kangaroo, *Phascolomys*, "potaro" (*i.e.*, rat kangaroo), "peramle" (*i.e.*, *Perameles*, bandicoot), "phalangers, *Dasyurus* or native dog [the description being apparently that of the Tasmanian wolf and not the dingo], vulture, cream-bellied falcon, orange-speckled hawk, milk-white hawk, owls (his description applying to the boobook owl), parrots, cockatoos, paraquets, cassowary or emu, black swan, heron, wild turkey, bronzewing pigeon, enormous whales, seals, dolphins, sea serpents, huge cuttle fish, and Nautilus."

On November 26, 1839, there was exhibited at a meeting of the Zoological Society of London (P.Z.S., 1839, 172) a collection of marine specimens from Kangaroo Island, forwarded by Dr. J. B. Harvey. In the following year the latter (1841) wrote "A Sketch of the Natural History of Port Lincoln" in the South Australian Magazine, vol. 1, and referred to various mammals generically as *Sorex, Mustela, Nasira* (apparently meant for *Nasua*), *Myoxus* (all of these obviously in error); and to others as *Phascolomys, Macropus, Dasyurus,* etc.; also to three species of *Phoca,* two of them being hair seals and one a fur seal; and to various Cetaceans (*Delphinus, Physeter, Balaena, Grampus,* finback, and thresher). The house mouse, *Mus musculus,* and the brown rat, *Mus decumanus,* were stated to occur there. The wild dog (*i.e.*, dingo) was referred to as *Hyaena viatica.* These various identifications were reviewed in 1909 by Zietz.

In addition to Harvey's article, several others of a zoological nature appeared in the South Australian Magazine, vols. 1 (1841-2) and 2 (1842). There is a review of Gould's Birds of Australia, Part 1 (1841) and his descriptions of two South Australian birds, *Trichoglossus porphyriocephalus* and *Pedionomus torquatus*, are republished. Hart referred incidentally to the whale fishery at Encounter Bay. Bentham described Port Lincoln and its neighbourhood, referring to the oysters; the abundance of Cape geese *(i.e.,* Cape Barren geese), kangaroos, wild ducks and seals; the mutton birds *(i.e., Puffinus* spp.), whose eggs were used as food; and the prevalence of whales and whalers (1841). Wilson, under the name "Naturae amator," published a series of "Notes on the Natural History of South Australia"; Nos. 1 and 2 in 1841 and Nos. 3 to 7 in 1842, but most of them dealt with insects, the remainder referring to native birds, seashore shells, whales and porpoises. As already mentioned, Wilson contributed a number of articles on the local entomology to "The South Australian Register" in 1841. This active entomologist published in the "Farm and Garden" (an Adelaide monthly) vols. ii to v (1859 to 1863), a number of articles on injurious insects; and in Proc. Ent. Soc., London, 1864, "Notes on the Entomology of South Australia."

In the Adelaide Miscellany, vol. i (1848), Davis published three entomological articles, and in vol. ii (1849) others dealing with snakes, fish and seashore molluscs, as well as a "Naturalist's Calendar," giving the date of appearance of various birds, insects and blossoms.

In 1845 there appeared Eyre's "Journal of Expeditions of Discovery into Central Australia, etc., 1840-41." It contained appendices (vol. i) by Gray dealing with a bat, reptiles, frog, crayfish, a mollusc and a Spatangoid; Richardson on fish; White on insects; Gould on birds; and Doubleday on Lepidoptera.

In 1846, G. R. Waterhouse published his "Natural History of Mammalia," vol. i, "Marsupiata," and in it referred to various South Australian species, including *Macropus fuliginosus* (Desmarest, 1820), whose locality is quoted (?) Kangaroo Island; *Lagorchestes leporoides,* described by Gould (P.Z.S., 1840) from the plains of the Lower Murray (South Australia), and *Macropus greyi* Gray (List of Mammals Brit. Mus., 1843), based on a specimen sent by Governor Grey. In 1847 Angas published figures of local kangaroos and insects in his "South Australia Illustrated."

Francis wrote a series of articles on Australian mammals and birds in "The Farm and Field," vols. iv and v, published in Adelaide, 1861-1863. Gould referred to some South Australian birds in his great Monograph (1848) and Handbook (1865), and to some mammals in his work on the "Mammals of Australia" (1863). He had previously described marsupials in 1840, and a rodent *(Leporillus apicalis)* in 1851. Krefft dealt with some vertebrates from the Lower Murray in Tr. Phil. Soc., N.S.W., 1865; and with our snakes in his book "On the Snakes of Australia" (1869). Sclater referred to some of our mammals in 1865.

An account of McDouall Stuart's "Explorations across the Continent of Australia, 1861--2," was published in Melbourne in 1863; and his "Explorations in Australia . . ." (1858 to 1862), published in London in 1864. The latter work contains appendices by Gould on the birds (the account appearing also in P.Z.S., 1861); Angas and Adams on Molluscs (also in P.Z.S., 1863); and Pfeiffer on a land snail. A report by F. G. Waterhouse on the fauna and flora of the region traversed by the expedition appeared as a South Australian Parliamentary Paper in 1863.

Angas published a number of papers relating to South Australian mollusca in P.Z.S., 1865, 1868, 1871, 1873, 1875, 1876, 1877 and 1878; Baird referred to some of our polychaetes in his papers in the Jour. Linn. Soc. (Zool.), London, 1864-1870; Milne-Edwards to Crustacea in 1840; C. S. Bate to amphipods in

1862; Duncan to Tertiary corals and echinoderms (Ann. Mag. Nat. Hist., 1864, 1865, and Q. J. Geol. Soc., 1877); Laube to Tertiary echinoids (S.B. Akad., Wien, 1869). Parker and Jones wrote on Foraminifera from the Mount Gambier Polyzoal limestones (Q.J., Geol. Soc., 1860); Tenison Woods on various Tertiary deposits (T. Phil. Inst. Vict., 1859; Q.J., Geol. Soc., 1860; T.R.S., Vict., 1865), molluscs (T.R.S., Vict., 1877), Polyzoa (J.R.S., N.S.W., 1877), Echinoids (P.L.S., N.S.W., 1877), and Corals (P.L.S., N.S.W., 1878); Busk on Polyzoa from Mount Gambier (1860); Etheridge on our Tertiary Brachiopods (Ann. Mag. Nat. Hist., 1876), Post-tertiary Foraminifera and Ostracoda (Geol. Mag., 1876), as well as Tertiary Polyzoa (J.R.S., N.S.W., 1877); Gray on lizards (1867); Cox on land shells (1868), and on Volutes (1872); and Brazier on molluscs (1872, 1875).

Waterhouse's "Classified Catalogue of mammals and birds met with in South Australia" appeared in W. Harcus' "South Australia" in 1876. Castelnau described many of our fishes in Pr. Zool. Acclim. Soc., Victoria, vols. i (1872) and ii (1873). Andrews contributed a report on the fauna, fossils, etc., of Lewis's Exploring Expedition (appearing as a S.A. Parliamentary Paper in 1876); and published a series of ten articles entitled "Notes on the Zoology of South Australia" in the South Australian Chronicle (1877). Tate wrote on our Tertiary Belmnites (Q.J., Geol. Soc., 1877) and our Tertiary Ostracods and Foraminifera (Geol. Mag., 1877).

These dates bring us forward to the time when the Royal Society of South Australia began its career, but it would now be advisable to consider the contributions to zoological knowledge made through its predecessor, the Adelaide Philosophical Society, which was founded in January, 1853. Its first Report (January, 1854) stated that "matters directly relating to the natural history of the colony have been the subject of occasional discussions at the meetings . . . Intimately connected . . . is the formation of a Museum for the preservation of specimens illustrative of the natural history of the colony." Of the ten papers read in 1853 and published in abstract, three were zoological—one by Hammond dealing with the structure and uses of the hand; one by Wilson on the saltatorial motions of animals; and one by Bompas on the nervous system of invertebrates. Of the nine papers abstracted in the second Report (January, 1855), three were zoological—by Wilson, on the saltatorial power of animals (Part 2); by Gosse, on respiration; and by Bompas on the circulation of blood. The third Report (1856) stated that the Council had most unwillingly been forced to decline natural history specimens because of the delay in establishing a Public Institute on account of the financial state of the Colony. Two of the nine papers abstracted were—one by Davis on human spontaneous combustion; and one by Little on the supposed footprints of a gigantic saurian. The fourth Report (1857) referred to the establishment of the South Australian Institute and contained abstracts of two zoological papers—both by Wilson, one dealing with the raptorial power of animals, and the other with wood boring insects of the State. In the fifth Report (1858) reference was made again to the need for a Museum, and the hope was expressed that the governors of the South Australian Institute would obtain parliamentary authority to proceed with its establishment. The report contained an abstract of two papers on mesmerism. Reports from the seventh to the eleventh, inclusive, are not available to me, and it seems probable that these were not published; but in 1862 Francis read before the Society a paper on the acclimatisation of plants and animals, this being published in the same year. The twelfth Report (1865) mentioned the titles of several zoological papers read, but of the nine published three, written by Tenison Woods, were zoological and dealt with the molluscs and brachiopods of the Tertiary rocks of the State; while the next Report (1866) included a paper on the Tertiary echinoids, by the same author. In the fourteenth

Report (1867) there is a short paper by Waterhouse on *Stylops;* while the fifteenth (1869) and sixteenth (1870) contain no articles of zoological interest. The seventeenth (1871) included a paper by Lloyd on the camel in South Australia; and two papers relating to silkworm culture, one by Reed, and the other by Schomburgk. The eighteenth Report (1872) covered the work of two years (1871, 1872) and included a paper by Rutt on the flight of birds, considered with reference to aerial navigation; and one by the Chief Justice, Sir R. Hanson, on the theory of evolution.

As far as known to me, the Philosophical Society did not add much original research work in Zoology apart from that of Tenison Woods. It was the appointment of Ralph Tate to the newly-established chair of Natural Science in the University of Adelaide, which led to the founding of the Royal Society on the foundation of the moribund Philosophical Society, and to a greatly awakened interest in scientific research.

Tate was especially interested in Botany and in the Mollusca, and also devoted much attention to Geology and Palaeontology. He was elected to be the first President of the reorganised Philosophical Society, which two years later altered its name to Royal Society, and his presidential address was of a very high order and appears as the first paper in our Transactions. That address referred, in part, to Australian Zoology generally, but made special reference to South Australia where possible, mentioning Waterhouse's Classified Catalogue of our mammals and birds (1876) Krefft's book on Australian snakes (1869); Angas' list of all known South Australian species of marine mollusca (1865); Bednall's list of our marine shells (1874); as well as others. The various groups of our insects were also reviewed. Tate's address made an excellent beginning for the new publication and set a very high standard, which was reflected in the other papers which comprise Volume I of our Transactions. Tate also took a leading part in founding the Field Naturalists' Section of our Society.

The other name which stands in the forefront of scientific activity on the zoological side in South Australia is that of Sir Joseph Verco, a pillar and benefactor of our Society, and for eighteen consecutive years its active President. His obituary notice appears in our volume for 1933. To him we owe largely our endowment fund, which has been of such assistance to the Society in publishing scientific work. Verco was himself an ardent worker in Conchology, especially after Tate's death, and carried out extensive dredging along the continental shelf from Beachport to Fremantle, his material (other than molluscs) being distributed to other investigators for study and report. His work on behalf of our Society was recognised by the institution of the Verco Medal for Research. He took a very important part in the medical life and in medical education in this State, and by his generous gift to the University of Adelaide was instrumental in placing on a sound financial footing the Australian Journal of Experimental Biology and Medical Science. This serial, issued in four parts annually by the University, is an avenue for the publication of high-class papers on experimental work in physiology, zoology, botany, bacteriology, etc.

It is not proposed to enter into any detail regarding the various zoological papers appearing in our Transactions, but rather to group them and to indicate after the author's names the years (in abbreviated form) in which the volumes containing their contributions appeared. This arrangement will provide ready reference to the papers dealing with any particular group of organisms. Figures in parenthesis following the year indicate the number of papers on the subject published by the author in our volume in that year.

The Presidential Addresses appearing in our Transactions and having a definitely zoological interest are those given by Tate (78, 80, 95), Stirling (90,

on Weissmann's theory of heredity), Rennie (03, on the Fisheries of Australia), and Howchin (97, on Foraminifera).

As would be expected, the mammalia have received considerable attention. Stirling published a number of papers relating to the marsupial mole, *Notoryctes typhlops* [89, 91 (2), 94]; while Wilson (94) and Elliot Smith (95) described the myology and brain, respectively. Wood Jones contributed a series of short papers dealing with the external features of the pouch embryos of marsupials [20, 21, 22, 23 (3), 24 (2)], as well as many others relating to the morphology and classification of marsupials, rodents, seals, dingo, etc. [21, 22, 23, 24 (2), 25, 27]. Finlayson has taken up the study of the Australian mammalian fauna and has published a number of papers on structure and especially habits [27, 30 (2), 31 (2), 32 (2), 33 (3), 34, 35 (2)]. His rediscovery of the long-lost *Caloprymnus campestris* Gould, is noteworthy (31, 32). Other contributors are Zietz (90, List of South Australian Cetacea; 92, List of our wallabies and kangaroos; 06), Stirling (99, *Phascolonus)*, Stirling and Zietz (93, Elder Expedition, mammals), Haacke (84), and Waite (14, 15, 17).

Information regarding birds was published by Stirling and Zietz [93, Elder Expedition; 96 (2), fossil Struthious bird from Lake Callabonna], Zietz (00, 11), White (14, 15, 17), Morgan (97, 98), North (98), Hall (00), Andrews [83 (2)], Ashby (01, 29), Cleland (23), and Wood Jones (26). Lea examined the stomach contents of birds (14, 15, 17, 23) and his work has been continued by Gray, but the results have been published in the "Emu."

Reptiles have received attention from Zietz [88 (2), 99, 14, 15, 17], Stirling and Zietz (93), Stirling (12), Tepper (82), Proctor (23), and Waite (97, 14, 15, 17, 23, 27). Waite wrote on amphibians (14, 27). Papers dealing with fish were published by Zietz [02, 08 (3), 09], Waite (14, 15, 16, 23), and McCulloch and Waite [15 (2), 16, 17]; while Rennie (1903) discussed Australian fisheries. The only paper on Tunicata is that by Whittell (83).

The Mollusca have received a great deal of space in our Transactions—due largely to the energy and particular interest of Tate, Verco and Ashby. The following list includes papers on Tertiary as well as Recent molluscs, and in some cases Brachiopoda are also included. Tate's contributions number about 43, distributed between 1878 and 1900. They were published as follows:—78 (2), 79, 80 (3), 81, 82 (2), 86, 87 (5), 88, 89 (4), 90, 91 (2), 92 (2), 93 (3), 94 (3), 95, 98 (3), 99 (5), 00 (2). Tate and May (00). Verco's twenty-four papers on Mollusca appeared in 95 (2), 96, 04, 05, 06 (2), 07 (3), 08 (2), 09 (3), 10, 11 (2), 12 (3), 13 (2), 18. Ashby published twenty-six papers on the Polyplacophora (Loricata) in our volumes, as follows:—00, 18 (3), 19 (3), 20 (3), 21 (2), 22 (2), 23 (4), 24 (3), 26, 28 (2), 29, 30, as well as one in collaboration with Torr (98). Torr also published papers on the same group in 1911 and 1912. Other papers on Mollusca were those of Dennant (89, 94), Matthews (14), Riddle (15, 20), Woods (31), Bednall (78, 86, 93), Brazier (87), Cossmann (97), Torr (14), Basedow (02, 05), Basedow and Hedley (05), Hedley (05), and Maughan (00—on chitons).

Brachiopods received attention from Tate (80, 86, 87), Dennant (89), and Verco (10). The Polyzoa (Bryozoa) were studied by Tenison Woods (80), MacGillivray (89, 90), and Stach (36).

The arthropods occupy a preponderating part of our Transactions, largely because of the work of such entomologists as Blackburn, Lea, Tepper, Lower, Turner and many others, but these have been dealt with by Dr. Davidson (1936) in his address. There are no papers in our volumes dealing with Myriapoda; only one on scorpions (Glauert, 25); five on acarines—Banks (16), Holdaway (26), Hirst (29) and Womersley [33 (2)]; and six on spiders—Hogg (10), Rainbow (15, 17) and Pulleine (14, 19, 22). The lower Crustacea have received

no attention in our Transactions, except in part of a paper by Chilton (17). The higher forms have been studied more especially by Baker and by Hale. Baker's papers appeared in 04, 05 (2), 06, 07, 08, 10, 11, 13, 14, 26 and 28; and those of Hale in 24 (2), 25, 26, 27, 28, 29 (2). Other contributions are those of Zietz (88), Tate (83), Rathbun (29), and Chilton [17 (2), 22 (2)].

The Annulata received little attention in our volumes, there being two papers on Hirudinea, *viz:* by Leigh Sharpe (16) and Mrs. Best (31); and one on Polychaeta by Ashworth (16).

Helminthology was responsible for several papers, as follows:—Haematozoa of birds, by Cleland and Johnston (10), and by Cleland (15); *Linguatula* by Johnston (10), Trematoda by Johnston (27, 29, 34); Cestoda by Davies Thomas (83, hydatid disease), and Johnston (35); parasitic Nematoda by Johnston (21, 36), and Bull (19); Acanthocephala by Johnston and Deland [29 (2)]. The various endoparasites of *Trachysaurus* were discussed by Johnston (32). The life-history of the nematode, *Habronema,* was studied experimentally by Bull (19). Cleland (22) published a list of ecto- and endoparasites recorded from Australian birds.

The Echinodermata have formed the subject of papers by Tenison Woods (79, Echinoids), Tate (82, 91, 92, Echinoids), Joshua and Creed (15, Holothurians), and Mortensen (29, Echinoids).

The Coelenterata, apart from Corals, have not received attention in our Transactions. The chief worker was Dennant, who published between 1899 and 1906 his papers on Tertiary and recent corals—99 (2), 01, 02 (2), 03, 04 (2), 06. Others were Tenison Woods (78, 80), Tate (78), and Howchin (09), the last-named giving a bibliography for each of the twenty-four recent species recorded as occurring in South Australian waters. The Porifera are not represented by any papers in our volumes.

The Protozoa, apart from the Foraminifera and a few parasitic species, have also failed to secure representation. The Foraminifera have been specially studied by Howchin whose papers relate chiefly to Tertiary and Post-tertiary forms, but one of them deals with the estuarine species identified from the Port River (90). Howchin's papers were published in 86, 89, 90, 91 (2), 92, 93, 95 (2), 97, 99, and 15. Schlumberger contributed one in 1891. The parasitic protozoa are represented in papers on Haematozoa of birds, by Cleland and Johnston (10), and by Cleland (15); and on the protozoon entozoa of the stumpy-tailed lizard, *Trachysaurus,* by Johnston (32).

Ecological papers, based on entomological problems, have been published by Johnston (23, 26) and Davidson [34 (2), 35, 36]; Tiegs (22) contributed an excellent account of the embryology of an insect.

Amongst miscellaneous papers which might be classed satisfactorily under animal physiology, are those by Tiegs [22, 23 (2)]; and Robertson (05) on muscular action; Cleland on blood grouping (27) and on the sizes of the red blood cells of Australian vertebrates (15); and Robertson (20) on the physiology of the fly's intestine. The last-named author also published, in 1910, an address on recent experiments in chemical fertilization of animal eggs.

Zoological reports relating to the Elder Expedition appeared in 1892-96. Those of Captain White's Expedition to Central Australia to the east of the present railway to Alice Springs (1914), White's Expedition (with R. L. Jack) to the Musgrave and Everard Ranges (1915), and the South Australian Museum's Expedition (under Waite) to the east of Lake Eyre (1917) appeared in the volumes indicated by the dates mentioned. The fauna of the Nuyts and Investigator Groups has been studied by Wood Jones and colleagues (19-23). Tate investigated the natural history of the region around the head of the Great Australian Bight (1879), and of Kangaroo Island (1883).

The Memoirs of our Society contain important papers dealing with fossil animals from Lake Callabonna:—Stirling and Zietz on *Diprotodon* (99), *Phascolomys* or *Phascolonus* (13) and *Genyornis* (00, 05, 13). Cretaceous molluscs and brachiopods were reported on by Etheridge (02); and the Cambrian Archaeocyathinae by Taylor (10).

The Records of the South Australian Museum appeared first in 1918 and contain many zoological articles, but in the following account those on Entomology are omitted.

Cetacea were responsible for reports by Waite (19, 26, 22) and Hale [31 (3), 32]. Wood Jones contributed papers on rabbit bandicoots (23), jerboa mice (25) and the eared seals (25). Reptiles received attention from Waite [18 (2), 25], Waite and Longman (20), Zietz (20), and Kinghorn (35), the last-named referring also to Amphibia (35). Fish were described or recorded by Waite [21 (2), 22 (2), 24, 27], McCulloch and Waite [18 (2)], Whitley (35), and Hale (35). One of Waite's papers is a very important one, being an illustrated catalogue of South Australian fish, this report becoming the basis of his Handbook on our Fishes, published later for the British Science Guild.

The Crustacea are represented in papers by Hale [24, 25, 28, 31, 32, 36 (2)], Baker (26), Tattersall (27, 28), and Sheard [36 (3)]. Rainbow (2) contributed a paper on spiders; and Womersley two on Acarina (34, 35).

The various groups of Mollusca are responsible for many papers:—Verco (22, 24), Verco and Cotton (28), Berry (21), Ashby and Cotton (35, 36), Cotton [30 (3), 31, 32, 34, 35, 36 (2)], Cotton and Woods (33, 35), Howchin and Whitehouse (28, *Crioceras)*.

Other phyla represented are the Echinodermata by an important paper by Lyman Clark on Crinoids, Asteroids, Ophiuroids, and Echinoids (28); the Bryozoa, by Livingstone (28); and the Trematoda by Johnston (28).

Crawford published a number of short entomological articles in "Garden and Field," vols. vi to xi, as well as in P.R. Agr. Hort. Soc. S. Aust., 1881-1884. In the latter journal there were also articles written by him on ear-cockle of wheat, due to the Nematode, *Anguillula tritici* (1881); and on the Mite, *Phytoptus pyri* (1882).

The Australasian Association for the Advancement of Science held three meetings in Adelaide—in 1893, 1907 and 1924, the respective volumes being published there in 1894 (vol. v), 1908 (vol. xi) and 1926 (vol. xvii). They all contain papers of zoological interest. The volume for 1893 includes two papers by Howchin on fossil Foraminifera, one of them being a census of those known from Australia, the list being composed mainly of species from the Tertiary and Post-tertiary. Both Hedley and Blackburn dealt with aspects of the distribution of the Australian fauna; Campbell gave an account of the eggs of Australian Charadriid birds; and Dendy contributed a short paper on the land Planarians of Tasmania and South Australia. Barnard and Park drew attention to worm tumours, due to *Spiroptera* (now known as *Onchocerca gibsoni)*, occurring in Queensland cattle. The presidential address to the Biology Section was given by De Vis and entitled "Life." In the Handbook issued in Adelaide in connection with this meeting, Waterhouse published (1893) "The Fauna of South Australia," which was a list of the mammals and birds.

The report for 1907 includes a paper by Hedley and Taylor dealing with Queensland Coral Reefs, and one by the latter on the Archaeocyathinae. Brailsford Robertson gave an account of recent advances in our knowledge of protein salts and of their role in biological phenomena. Berry described a teratological lamb and offered a developmental explanation of the monstrosity. Cleland made

remarks on the natural history and diseases of rats from the vicinity of Perth and Fremantle. The presidential address by Maiden to the Biology Section, though not concerned with Zoology, may be mentioned because it is of special interest to this State; it was entitled "A Century of Botanical Endeavour in South Australia."

The volume for 1924 contains a presidential address by Agar on some problems of evolution and genetics; a paper by Chapman and Crespin dealing with Miocene fossils (chiefly Mollusca) from Western Australia; an entomological one by Froggatt; one by Longman on the uniqueness of the Australian fossil marsupials; and one by Ashby dealing with the regional distribution of Australian chitons. The Handbook published in Adelaide for the use of members at this Adelaide meeting (1924) contains brief articles on the marsupials by Wood Jones; reptiles and batrachians by Waite; birds by Morgan; insects by Lea; marine fauna and fishes by Waite; Crustacea by Hale; and Mollusca by Verco.

The Field Naturalists' Section of our Society was founded in 1883, largely through the influence of Tate, who became its first Chairman, with Whittell and Howchin as the two Vice-chairmen. In 1919 the South Australian Naturalist began its career. The history of the Section during the first fifty years of its existence was published in it (1933) by W. Selway, one of the few surviving members. As one might expect, the scope of the publication zoologically is largely limited to local notes and observations, and consequently most of the articles appearing in it do not call for comment in an address like the present one, but there are a few which should be mentioned. Hale, Brenn, Elston, Tindale, Holdaway and others contributed papers on entomological subjects; Hale on Crustacea (25, 30); Blewett on fish (29); Hale and Blewett on the parasitic infusorian, *Ichthyophthirius* (31); Walton on Mollusca from Outer Harbour —an ecological paper (24); Trigg (Shell Collectors' Club) on Mollusca (1926, etc.); Cotton on Mollusca (31, 33, 34); and especially Cotton and Godfrey who published, between 1931 and 1935, a series of fifteen well-illustrated articles containing descriptions of South Australian shells. The forthcoming booklet, to be issued by the Section, on the fauna and flora of the National Park, Belair, contains brief reference to its animal life.

The South Australian Ornithologist commenced publication in 1914. It contains numerous papers, most of them short, and many of them giving lists of birds seen in various districts. As one would expect, the volumes consist largely of observations on bird life, but there are occasional papers by Morgan (1932, etc.) which contain some physiological or anatomical data. A few papers call for special notice. Amongst these are Sutton's List of South Australian Birds (23); Howchin's (26) interesting survey of the literature relating to the extinct emu of Kangaroo Island; Parsons' article on the flight of birds (30); McGilp's account of South Australian hawks (34); Condon's identification of the albatrosses collected from our coasts (36); and Wood Jones' record of the breeding of *Puffinus gravis* in Tasmania (36).

The Medical and Scientific Archives of the Adelaide Hospital, volumes i to xv, published annually between 1922 and 1936, all contain one or more papers relating to cases of hydatid disease met with in that institution.

The pages of the Australian Journal of Experimental Biology and Medical Science are occupied mainly by papers on some phase of Animal Physiology, but other phases of Zoology are also represented. Papers have been published relating to parasitic Protozoa by Turner and Murnane [30 (2), trypanosomes; 32, *Giardia*]; *Rickettsia*-like bodies by Gordon (33); Piroplasmosis by Legg (26);

cytology of certain Infusoria by Horning [25, 26 (2), 27 (3), 28, 29]; growth of Infusoria in certain culture media by Robertson [24 (2), 25, 27]. The presence of Golgi bodies in *Hydra* was reported by Horning (28). Helminthology is represented by papers on Trematoda by Johnston [30 (2), 31, 34], and Kellaway (28, anaphylaxis and *Fasciola* extracts); on Cestoda by Johnston (31), Clunies Ross (27 Hydatid toxicity), Cameron (26, Hydatid enzymes), Kellaway and Williams (24, 28, Hydatid antigens); on Nematoda by Walker (24, Filarial life history), Fielding (26, 27, 28, *Oxyspirura* life history), Heydon (27, *Onchocerca*), Woodruff (27, *Onchocerca*), Clunies Ross (31, *Haemonchus*), and Gordon (33, *Trichostrongyles*). Ecological studies based on certain insects were published by Davidson [31 (2), 32, 33 (2)]. Sex ratio in certain insects was discussed by Holdaway and Smith (32, 33); and sex determination in *Thrips*, by Davidson and Bald (31). Mutation was observed in *Lucilia* by MacKerras (33). Australian snakes or their venoms were studied by Kellaway either alone or in collaboration with other workers [29 (2), 30, 31, 32 (4), 33 (2), 34 (2), 35, 36], by Holden (32, 33, 34, 35, 36), and by Thomson (30). Kellaway also investigated poisoning by mussels (35) and (with LeMessurier) the venom of the platypus (35). Duhig and Jones (28) dealt with the venom of a fish, *Synanceia*. Agar contributed a paper on experimental behaviour in some acarines and crustaceans (25), and also a review of the experiments relating to the inheritance of acquired characters (32). Papers on cytology were published by Horning [25, 26, 27 (3), 28, 29, 30], and Bourne (35); on tissue culture by Horning and his colleagues [29 (3)], and by Bourne (35); and on transplantation of tissues of chick embryos by Murray (28), and by Selby and Murray (28). Certain aspects of the physiology of aquatic organisms were studied by Dakin and Edmonds (31). Cleland dealt with blood grouping (26, 30).

Papers relating to some aspect of animal (including human) physiology, published by the following investigators singly or in collaboration with others, have appeared in the Journal. Anderson (24), Arden [34 (2)], Bollinger (32, 34, 35), Bourne [30, 34, 35 (4), 36], Cameron and Amies (26), Coates and Tiegs (28, 30, 31), Cotton [28 (2), 31, 32 (3), 35], Cox and Hicks [33 (3)], Dunn (33), Dawbarn [24, 28, 29, 32 (2)], Dickinson and Bull (31), Faul and Osborne (36), Freeman (34), Gay (32), Harker and Moppett (36), Hicks (26, 27, 31, 35), Hicks and colleagues [26, 31 32 (2), 33 (2), 34 (2), 35 (2)], Hindmarsh (27), Holden and others [28 (2), 32, 33 (2), 35], Horning (25), Hunter and Royle (24), Kellaway and colleagues [25 (2), 27], Lennox (35), Lines (32), Loeb (32), MacCallum (32), McLeod (32), Matters and others [29 (2), 34 (2)], Marston [32 (2)], Mitchell (24, 31, 36), Nord (36), Norris and others (29, 30), Osborne [24, 26, 28, 29, 30 (2), 31], Pierce (34), Robertson [26 (2), 28 (2), 29], Robertson and others [25 (2), 27, 29, 32, 33 (3), 34] Shaw [35 (2), Splatt (27), Thomas (33), Tiegs [24 (3), 25 (2), 26 (4), 27 (3), 29, 30, 32, 34], Underwood and Shier (36), Wardlaw and others [26, 28, 32 (2), 34, 35], Watson [33 (3)], Whetham (27), and Woollard (32). Papers which seem to be essentially biochemical have been omitted.

Experimental pathology is represented by papers by Albiston (27), Burnet (28), Hill (28), Kneebone and Cleland (26), Platt (36), and Turner (35).

The Proceedings of the Royal Geographical Society of Australasia, South Australian Branch, contain a number of papers of greater or less zoological interest, and these may be indicated thus:—Phillipson (95, Camel in Australia), Reed [40 (2), Oeconography, but the papers do not refer to Australian conditions], Dobbie (07, Coral islands and reefs), Mellor (09, Birds), Etheridge (18, Fossils, chiefly Brachiopoda), Hedley (18, Molluscs), Rainbow (18, Insects and arachnids), McCulloch (18, Fish and Crustacea), Briggs (18, Corals and

Polyzoa)—the last five authors dealing with material collected by Basedow in North-west Australia; Mawson (21, Fauna of Macquarie Island), Mrs. Bates (21, Animal Life at Ooldea), Newland (23, Whaling at Encounter Bay), White (24, Birds of the Finke River), Hodge (32, Whaling at Encounter Bay). Gill (1909) contributed an interesting article in vol. x on his visit to historic localities in the vicinity of the entrances to our two great Gulfs. In it he republished information from Flinders' and Peron's accounts, as well as from various authors, including Harvey's sketch of the natural history of Port Lincoln (1841), Zietz adding comments on the identifications. Moore, in 1924, published "Notes on the Early Settlers in South Australia Prior to 1836," and included many references to early sealers and whalers who visited Kangaroo Island and the adjacent regions from 1803 onwards.

The volumes of the Journal of the Department of Agriculture of South Australia, i to xxxix (1897 to 1936) have been searched and the following papers (after excluding those dealing with entomology) may be noted because of their zoological interest:—On Sarcosporidiosis, by Place (17); bee disease (due to *Nosema)*, by de Crespigny and Bull (13); plant parasitic Nematoda, by Editor (97, 99), Spafford (22), Davidson (30), Hickinbotham (30), and Garrett (34); endoparasites (chiefly Nematodes) affecting domesticated animals and stock, by Desmond [05 (2)], Place (12, 15, 18), Murray-Jones (14), Robin (26, 29), and McKenna (26, 33); Nematodes from fowls, by Laurie (10); Acarida, by Laurie (99, 13), Johnson (30), Lea (12), and Swan [34 (2)]; a series of illustrated articles on insectivorous birds, by Edquist (13); report on the distribution, migratory movement and control of starlings in South Australia, by Kinghorn (33); and on the pathology of the condition in eggs known as floating yolk, by Anderson and Platt (36).

The series of Handbooks of the Flora and Fauna of South Australia, issued by the Handbooks Committee of the British Science Guild (South Australian Branch) and published by the Government of this State, occupy a very important place in the record of local biological work. The various authors have prepared the manuscripts for these handbooks gratuitously, the Government setting aside a sum each year to allow of their printing and publishing by the Government Printer. Hence these books have been made available to the public at a very low cost. The committee controlling the preparation of these excellently illustrated books is a small one and its members (J. B. Cleland, J. M. Black, H. M. Hale (Editor), and T. Harvey Johnston) are all actively associated with our Royal Society.

Wood Jones dealt with the Mammals of this State, in a work issued in three parts, in 1923, 1924 and 1925, respectively, the whole account being authoritatively and interestingly written. Waite contributed the volume on fishes (1923), and (posthumously) that on reptiles and amphibia (1929). The higher crustacea have been handled in an excellent manner by Hale, whose account appeared in two parts (1927, 1929). All these works are amply illustrated and have appealed to a wide public. Other zoological handbooks are in active preparation.

The history of events leading up to the reservation, under the title of Flinders Chase, of a large tract of territory in the western portion of Kangaroo Island, as a sanctuary for the fauna and flora, was published in 1920 by S. Dixon.

The First Intercolonial Medical Congress of Australia (1887) held its meeting in Adelaide. Its transactions appeared in 1888 and contain a paper on *Echinococcus* of the brain, by Davies Thomas; and one by Creed on fear as a factor in producing many of the alarming symptoms following the bite of Australian snakes. The Congress met again in Adelaide in 1905 for its Seventh

Meeting, its publication (1906) being styled The Transactions of the Australasian Medical Congress. It contains the following papers:—By MacCormick and Hill on a larval cestode *(Sparganum)* from a human being; by MacCormick on cerebral hydatids; by Johnson on Trypanosomiasis; and by Tidswell and Flashman on the etiology of dysentery, amoebic dysentery being discussed in it.

Some of the earlier biological reports of the Australasian Antarctic Expedition of 1911-1914 were published in Adelaide. They include those on the Fishes by Waite (1916), and Mollusca by Hedley (1916). It is expected that several reports, now in the press and dealing with zoological collections made by the British, Australian and New Zealand Antarctic Expedition of 1929-1931, will be published in Adelaide during the present year (1936). They are those on the Birds by Falla; Loricata by Cotton, Collembola by Womersley; Coleoptera by Womersley; Brachiopoda by Cotton; Diptera by Womersley; Cumacea and Phyllocarida by Hale; Sundry Insecta by Womersley; and List of biological stations by Johnston.

Hodge, in his book on "Encounter Bay" (1932), devotes a chapter to early whaling in that district (1803-1851), and in another part refers to some of its birds, fish and larger crustacea.

In 1935 there was published in Adelaide "Combing the Southern Seas," by the late Sir Joseph Verco. This work was based on the diaries which he kept relating to his extensive dredging trips ranging along the continental shelf from Beachport to Fremantle. The publication was undertaken at the request of Lady Verco and was edited by B. Cotton, who illustrated it by a great many of his own drawings of species collected by Sir Joseph. There was added, as a republication, Verco's "Catalogue of the Marine Mollusca of South Australia," originally issued in 1908.

In 1935 Finlayson published his book, "The Red Centre," dealing amongst other matters, with some aspects of animal life in Central Australia. One chapter dealing with his re-discovery in the Eyre basin of the small mammal, *Caloprymnus campestris,* the "oolacunta," which had escaped observation for nearly a century after its description by Gould, and was believed to be extinct. Though published in Sydney, the book is mentioned here because of its particular interest to South Australia.

A very brief survey of the Zoology of our State was published by Johnston in "The Centenary History of South Australia," 1936 (pp. 336-38). Amongst the various South Australian smaller publications not issued under the aegis of any of the scientific societies mentioned above, the following have a zoological interest:—

W. T. Bednall: "List of South Australian Marine Shells" (1874).

D. J. Adcock: "Handlist of the Aquatic Mollusca Inhabiting South Australia" (1893).

J. C. Verco: "Catalogue of the Marine Mollusca of South Australia" (1908); reprinted in Verco's "Combing the Southern Seas" (1935).

J. Davies Thomas: "Hydatid Disease, with Special Reference to Its Prevalence in Australia." (Government Printer, Adelaide, 1884.)

J. Davies Thomas: "Hydatid Disease of the Lungs." (Adelaide, 1884.) Other papers and books by this author were published outside South Australia.

W. Howchin: "Native Animals of South Australia." (Department of Intelligence, Bull. 14, 1910, Adelaide.) Refers to vertebrates only.)

T. P. Bellchambers: "Nature, Our Mother." (Adelaide, 1918.)

List of books on Ornithology in the Public Library of South Australia. Adelaide, 1926.

From the foregoing survey, it will be seen that much work remains to be done in the sphere of Zoology in South Australia. Apart from the Mollusca, higher Crustacea and certain groups of Insecta, comparatively little is known of our invertebrate fauna—in fact, there are great groups which are practically unstudied. One might mention the Protozoa (apart from the Foraminifera), Turbellaria, Nemerteans, free-living Nematoda, Chaetognatha, and Tunicata. The identification of our Coelenterates (apart from Corals), Sponges, Rotifera and Annulata has been incompletely carried out. Even the local parasitology in which the present author is more particularly interested, is very little known. The lower Crustacea, as well as many of the insect families, would repay study.

The ecological relationship of the fauna constitutes an almost untouched field. Embryology of our marine forms is likewise almost unknown. Fisheries problems await investigation. Cytology and genetics offer wide fields for zoological research. The main direction in which our energies are likely to be directed for a considerable time in the future, as far as Zoology is concerned, will probably be along morphological, embryological and ecological lines.

# CENTENARY ADDRESS NO. 7
# PROGRESS IN KNOWLEDGE OF THE GEOLOGY OF SOUTH AUSTRALIA.

*BY SIR DOUGLAS MAWSON, D.SC., F.R.S.*

**Summary**

One hundred years ago almost nothing was known of the geological features of the large region now included within the borders of this State. All that had been gleaned at that date is comprised in the casual observations of the earliest explorers. With the rapid extension of settlement following the establishment of the Province in the year 1836, knowledge of its geography and of its simplest and broadest geological features was steadily developed. The early discovery of rich copper deposits at the Burra, Moonta and Kapunda undoubtedly quickened public interest in geological affairs.

## CENTENARY ADDRESS No. 7

# PROGRESS IN KNOWLEDGE OF THE GEOLOGY OF SOUTH AUSTRALIA.

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### Introductory Bibliographic Review.

One hundred years ago almost nothing was known of the geological features of the large region now included within the borders of this State. All that had been gleaned at that date is comprised in the casual observations of the earliest explorers.

With the rapid extension of settlement following the establishment of the Province in the year 1836, knowledge of its geography and of its simplest and broadest geological features was steadily developed. The early discovery of rich copper deposits at the Burra, Moonta and Kapunda undoubtedly quickened public interest in geological affairs.

However, as there were then in the Colony but few competent geological observers and but little facility for the publication of such knowledge as was acquired, the first 42 years after the founding of the State served only to lay broad and imperfect foundations upon which the subsequent more exact and comprehensive rendering has since been achieved.

This primary period in the evolution of geological knowledge of the State terminated in 1878 with the inauguration of the Royal Society of South Australia, which event initiated a new era of progress in all sections of natural science. No department of scientific enquiry received greater impetus, at that time, than Geology, for the person mainly interested in the launching of our Society was Ralph Tate, himself a geologist, who had arrived in the Colony in 1875 to occupy the Chair of Natural Science at the University of Adelaide.

Tate's Presidential Address, which appears in the first volume of the Society's Transactions, contains a valuable bibliographic summary of publications bearing on the Geology and Palaeontology of the State published to that date, thus covering the primary period of our review. Tate's list of works relating to general geology, but not including purely palaeontological contributions, amounts to 15 in all. A further 17 palaeontological papers dealing with South Australian Tertiary fossils are also cited. At that time no pre-Tertiary fossils had been discovered within the boundaries of the State.

Of the contributions to general geology that had appeared at that time the more important are the following:—

Publications of the Rev. J. E. Tenison-Woods; more especially his well-written "Geological Observations in South Australia," printed in England in 1862.

Reports on the mineral resources and the geology of portions of the State, respectively, by A. R. C. Selwyn in 1859, and by G. H. F. Ulrich in 1872, published as Parliamentary papers.

Finally, there appeared in 1875 a "First Sketch of a Geological Map of Australia" by R. Brough Smyth. Of this Tate remarks it "embodies the labours of Selwyn and Woods and the inedited observations of our Survey Department and of some explorers."

The embryonic state of geological knowledge even in 1875 is well portrayed by this first geological map, for therein, within the boundaries of South Australia, cognisance is taken of only three divisions, namely, Tertiary, Silurian and Igneous; even so, it is greatly in error.

The 58 years that have elapsed since 1878 have been a period of steady and fairly rapid progress in the elucidation of the geological fabric of the country. In this our Society has played a direct part, as is evidenced by the large number of contributions on geological subjects printed in the Society's volumes. Further, by its action in helping to secure the appointment, in 1883, of the Government Geologist, an office which had not existed prior to that date, the Society has greatly promoted geological science in this State.

The distribution of literature in the form of original contributions to the Geology and Palaeontology of South Australia that have appeared since Tate's address in 1878, may be briefly summarised as follows:—

Firstly, the Geological Survey reports and various reports by the Government Geologist and others, which have been printed at the Government Printing Office as Parliamentary Reports or as productions of the Geological Survey Department, are embodied in about 200 separate publications; included amongst these are coloured maps issued, respectively, at successive intervals illustrating the distribution of the various geological formations as known at the time of printing. Shortly after his appointment as Government Geologist, Dr. L. K. Ward included as an addendum to his annual report for the year 1915 a catalogue of official publications dealing with the geology and mineral resources of South Australia; this is a valuable reference list, complete to that date.

Apart from the official publications of the Geological Survey, the volumes of the Royal Society of South Australia are outstanding as a source of published information concerning the geology of the State. Comprised within the regular annual volumes of transactions and the special quarto memoirs of the Society which were issued some years ago, there are about 191 contributions on general geological and mineralogical subjects and about 60 of a purely palaeontological nature, all relating to matters within this State. In addition there are 16 papers dealing with the geology of Central Australia and the Northern Territory, most of which by the geographical proximity of that region have a direct bearing on the geology of the northern areas of our State.

A third source of published information, in the nature of original observations on the Geology of South Australia, are the volumes of the Australasian Association for the Advancement of Science (now the A.N.Z.A.A.S.). In these are to be found some valuable summaries relating to certain aspects of the subject. One of these deserves special mention here; I refer to Professor Ralph Tate's Presidential Address delivered in the year 1893, "A Century of Geological Progress," in which he traces the rising tide of geological knowledge of Australia and Tasmania during the first 100 years of colonization. In all, there appear in the Science Association's volumes 35 papers relating to South Australia that are of a general geological nature, and 5 that are purely palaeontological; 7 other contributions refer casually to South Australian matters, and 3 deal with Central Australia contiguous to South Australia.

In the above three publications are to be found the main bulk of all original observations relating to South Australian Geology. About another dozen contributions bearing on our local geology are to be found in the Proceedings of the Royal Geographical Society of Australia, S.A. Branch.

Some important contributions are contained in works published outside the State, of which the following have come under my notice.

Many papers dealing with the Tertiary marine rocks and fossils of Victoria, published in the Proceedings of the Royal Society of Victoria, make some reference to corresponding beds in this State and their fossil contents.

Reference to Cretaceous fossils forwarded by H. Y. L. Brown and determined by W. H. Hudleston appears in the Geological Magazine of 1884, page 339. In the same magazine, page 342, H. P. Woodward supplied notes on trilobites,

etc., from Ardrossan, forwarded to him by Tate and Brown. Again, in the Geological Magazine of 1885, page 289, H. P. Woodward describes Mesozoic and Tertiary (?) plant remains from Leigh's Creek and Mount Babbage. At a much later date, Dr. C. E. Tilley published in the Geological Magazine important petrological papers on Pre-Cambrian rocks of Eyre Peninsula (vol. lvii, p. 449 and p. 492; vol. lviii, p. 251, and vol. lxii, p. 309).

In a paper published in the Proc. Linn. Soc., N.S.W., vol. xxi (1896), pp. 571-583, T. W. E. David and W. Howchin relate the occurrence of radialaria and oolitic structure in South Australian Pre-Cambrian (?) rocks and discuss the question of age of the Brighton Limestone and associated beds.

In the Q.J.G.S. Howchin has written on the Sturtian Tillite [vol. lxiv (1908), p. 234]. In vol. lxxxii (1926), p. 332, Cretaceous glaciation in Central Australia is referred to by T. W. E. David and W. G. Woolnough. There is also another paper on some algal limestones of South Australia [vol. lxxxv (1929), p. 613]. In addition, there have appeared in this Journal, in recent years, several important papers by Dr. Madigan and others on the geology of Central Australia, which observations have a special interest to South Australia.

A notable paper by Dr. C. T. Madigan dealing with the Lake Eyre Basin is to be found in the Geog. Journal, vol. lxxvi, p. 216.

As long ago as 1894 Dr. C. Chewings contributed original observations in a dissertation for the doctorate degree at Heidelberg University, published as "Geologie Süd und Central-Australiens" by the Heidelberg University press.

Important summaries relating to the geological features of South Australia have appeared in certain of the Commonwealth Handbooks (see especially 1914 and 1920) and in handbooks issued in connection with Adelaide meetings of the A.A.A.S. In the Proceedings of the Pan Pacific Science Congress of 1923 (Sydney) there are references to South Australia in relation to the Marine Tertiary formations of southern Australia.

Professor W. Howchin's "Geology of South Australia," which first appeared in 1918 and again as a revised edition in 1929, assembles under one cover most of the accumulated knowledge concerning the geology of this State.

Howchin's production, "The Building of Australia and the Succession of Life," which appeared in three parts between the dates of 1925 and 1930 as a handbook of the British Science Guild (South Australian Branch), may also be consulted, but the purely geological matter contained therein is marshalled from his preceding work and other published matter.

In 1932 Sir T. W. Edgeworth David's "New Geological Map of The Commonwealth of Australia" and accompanying book of "Explanatory Notes" were published by the Commonwealth Council for Scientific and Industrial Research. This work incorporates some previously unpublished matter and, so far as is within its scope, it brought the subject of South Australian Geology right up to date at the time of publication.

Memoirs, by R. and W. R. Bedford, No. 1 (1934) and No. 2 (1936), of the Kyancutta Museum (a private museum in S.A.), dealing with new species of Archaeocyathinae and other organisms, have recently appeared.

This year Messrs. Angus and Robertson have published a memoir by the late Sir T. W. Edgeworth David and R. J. Tillyard on Fossils of the Late Pre-Cambrian from the Adelaide Series.

Thus outlined in the foregoing paragraphs is the distribution of original literature on the subject of this address. Other expositions of South Australian geological features as recapitulations of already published matter are to be found in British, American and German publications.

The principal contributors to this mass of literature were, firstly, officers of the Geological Survey, more especially H. Y. L. Brown, Dr. L. K. Ward and Dr. R. L. Jack. The work of the Survey Department has of necessity been concentrated mainly upon economic matters.

Secondly, a large and very important share in the unravelling of the geological history of the State and in the detailed scientific treatment of some of the problems presented has been achieved by geologists associated with the University. Mention may be made of Professor Ralph Tate and Professor Walter Howchin in earlier times, whilst in more recent years the number co-operating in these investigations has greatly expanded, including, especially, Sir T. W. Edgeworth David, Dr. W. G. Woolnough, Dr. W. N. Benson, Dr. W. R. Browne, Dr. C. T. Madigan, Dr. C. Fenner, Dr A. R. Alderman and Mr. P. Hossfeld. My own observations have been devoted largely to the investigation of the older rocks of the North-Eastern areas.

Finally, some notable contributions to the common task have come from investigators not associated with either of the above institutions, as is exemplified by the very important foundational work of the Rev. J. E. Tenison-Woods.

## The Problem of the Older Rocks.

We will now turn to a review of some of the outstanding problems that have faced geologists in this State.

To begin with, the stratigraphy of the very large areas of ancient rocks containing little or no fossil remains is a problem yet only partially solved. Based on conjecture only, these and the somewhat less ancient terrain, now recognised as Cambrian, were figured in the earliest maps as Silurian. The first positive information bearing on their age was the discovery by Mr. Otto Tepper, in 1878, in limestone near Ardrossan, of trilobites and coral-like fossils (Archaeocyathinae). It was immediately recognised that this discovery demonstrated the occurrence of beds of older Palaeozoic age, but it was not until several years later that the age was finally fixed as Cambrian. Thus a section of the older rocks of Yorke Peninsula came to be recognised as Cambrian, whilst a crystalline formation disposed unconformably beneath them was then relegated to the Pre-Cambrian. The great mass of older rocks forming the Mount Lofty Ranges still defied analysis, and it was Tate's opinion, in 1893, that they were all Pre-Cambrian and would be found to be without fossils. However, in 1896, when in company with Howchin on a visit to Selwyn's rocks in the Inman Valley, Professor David discovered Archaeocyathinae fossils in the limestone of the Normanville-Sellick's Hill belt. At that time, on account of the fact that over large areas in the Mount Lofty Ranges the dip of the sediments is in a general easterly direction, Tate was of the opinion that progressively newer beds would be found towards the east side of the Range. The metamorphic and igneous areas of the central and eastern belts were at that time interpreted as the result of subsequent igneous injection.

Howchin laboured for long endeavouring to unravel the structure and sequence of beds of the western flank of the range near Adelaide. He demonstrated the faulted character of the formation and finally succeeded in presenting the sequence of a vast series of sedimentary beds unconformably overlying the crystalline complex, to which Woolnough had given the name Barossian on account of their strong development in the Barossa Ranges. Though no perfectly continuous series was proved in the vicinity of Adelaide, yet Howchin was then of the opinion that the fossiliferous Cambrian beds of Sellick's Hill were the topmost members of a continuous series of sediments extending down to the

underlying Barossian terrain. Accordingly all those beds overlying the Barossian were regarded as of Cambrian age.

The Sellick's Hill-Normanville formation and like beds distributed elsewhere in the State containing undoubted Cambrian fossils were referred to as Upper Cambrian. The underlying series, apparently unfossiliferous or almost so, well developed in the environs of Adelaide, was relegated to the Lower Cambrian.

Later, with the progress of investigations elsewhere in South Australia, it became apparent that these "Lower Cambrian" beds were developed over large areas of the State without any association of the fossiliferous Cambrian ("Upper Cambrian"). Further, no clear cut succession, without a break, from the "Lower Cambrian" to the "Upper Cambrian" had been demonstrated. Consequently, as the horizon of Archaeocyathinae elsewhere in the world had proved to be low down in the Cambrian, it then appeared likely that Howchin's thick "Lower Cambrian" formation is in reality Proterozoic. This contention is supported by the occurrence in it of a glacial horizon located near its upper limit, a feature which has been recorded elsewhere in the world in late Pre-Cambrian times.

In any case, it seemed desirable to distinguish by some relevant name this thick series of somewhat uncertain age. Many years ago I suggested to the late Sir T. W. Edgeworth David the adoption of some non-committal term such as "Adelaide Series" to designate this thick series of sediments.

This distinguishing name met with Howchin's approval and has since been adopted. It signifies the thick sediments of the neighbourhood of Adelaide, lying between the Barossian (older Pre-Cambrian) formation below and the fossiliferous Cambrian beds above.

It has long been recognised that investigation of the Adelaide Series extended beyond the type locality may supply evidence for subdivision into several stages, which subdivisions may even be separated by stratigraphical breaks. Unpublished evidence from our northern areas garnered long ago has supported this contention. Recently Paul Hossfeld, discussing a northerly extension of these beds, has produced evidence for dividing the Adelaide Series into two sections separated by an unconformity. He recognises a lower division referred to as the Para Series, including from the base as far as the Upper Phyllite horizon, just below the Mitcham and Glen Osmond Quartzites. The balance of the Adelaide Series is comprised in his upper division, styled the Narcoota Series.

Hossfeld's extensive field observations assist materially in defining, over a considerable area in the Mount Lofty Ranges, the limits of the Barossian formation.

Dr. Madigan's geological mapping of the western scarp of the southern section of the Range has defined the existence of a complete overfold in the neighbourhood of Sellick's Hill, so that the fossiliferous Cambrian beds appear to underlie older non-fossiliferous strata.

The complete elucidation of these older formations of the State is still our greatest problem. It will be seen that already much has been published concerning them. But since great areas of rocks of this class exist in our northern areas, it will be long before they are fully explored.

The basement complex so widely outcropping in this State presents a mine of intensely interesting problems that will occupy petrologists for generations to come. With these are associated important problems in ore formations of considerable economic interest.

Only two determinations of age based on radioactive disintegration relating to these old rocks of South Australia have yet been made. It is obvious that an extension of such age estimations is most desirable.

## Mesozoic Formations.

Another formation much newer than the older rocks just considered but widely extended in South Australia is that which forms the Great Artesian Basin. On account of its location in the far interior, this system of rocks did not come much under notice of geologists until the eighties of last century. Tate was the first, in 1877, to distinguish a fossil *(Belemnites australis)* from Stuart Creek as indicating an area of Mesozoic age. Two years later he expressed the opinion that fossils from this area were of Cretaceous facies. H. Y. L. Brown's official geological may of the State, published in 1885, represents a widespread region around Lake Eyre as "Mesozoic (Cretaceous and Oolite) with or without overlying Tertiary beds." The exploration of the limits of the Cretaceous basin was rapidly extended and finally finished by Brown in 1904.

In the meantime other Mesozoic formations had turned up. In 1885 Woodward described fossil plants of Mesozoic age from Leigh Creek. Attention was drawn to the coal-bearing beds in this locality in 1889, when Brown referred to them as Cretaceous (?) Later, in 1891, Etheridge, having examined a series of plant fossils from those beds, placed them under Lower Mesozoic. More recently, with the increasing knowledge of Australian Mesozoic flora, the Leigh Creek beds have been finally relegated to the Triassic.

Carbonaceous beds underlying the marine Cretaceous strata of the Artesian Basin have been located on the western limit of the Cretaceous area, near Lake Phillipson and at a locality just north of the northern tip of the Flinders Range at Kuntha Hill. The exact age of these beds has not yet been determined. They are variously referred to the Triassic and to the Jurassic periods. Artesian bores sunk through the Cretaceous formations have yielded additional evidence indicating the widely extended occurrence of these early Mesozoic formations as a basement feature of the Artesian Basin area. It is to be hoped that further exposures of these beds may be found to afford opportunities for their more critical study, for knowledge of them is yet all too vague.

Having regard to the extensive area occupied by Cretaceous beds in this State, little intensive examination of the series has yet been undertaken, and should well repay investigation. Dr. Whitehouse, of Brisbane, an authority on the Cretaceous beds of the Artesian Basin, has had the opportunity of examining fossils from the South Australian region and has thus been able to materially assist in the zoning of our formations, but more detailed palaeontological and stratigraphical work remains to be done.

## The Tertiary Marine Beds.

Turning now to a late but very important feature of South Australian strata, we remark the sweep of Tertiary marine beds which range along much of the coast and extend far inland in the region of the Bight and in the area that Tate designated as the Muravian Gulf, where in Miocene times the sea extended far up towards Broken Hill. These Marine Tertiary formations are well exposed in coastal cliffs and in the banks of the Murray River in its lower course. Thus they came under observation at a very early date. Peron, in 1810, described a limestone of this formation met with at Kingscote, and in 1833 the explorer Sturt found that the Murray River, in its course through South Australia, cut its channel down through fossiliferous marine limestone which he referred to the Eocene.

Tenison-Woods, between the years 1859 and 1865, spent much time investigating these limestones in the South-Eastern district, but it was not until Tate's arrival in South Australia that rapid progress was made in their stratigraphy and palaeontology. In 1878 Tate divided the Older Tertiary of the Aldinga and

River Murray cliffs into two series, Eocene and Miocene. These two divisions were subsequently found to be a general feature throughout the areas occupied by our marine Tertiary formations. Throughout succeeding years there was much controversy as to the exact age of the beds. Eventually, some 30 years ago, as a result of intensive investigation of their foraminiferal contents, Mr. F. Chapman gave good grounds for stepping down Tate's Eocene to Miocene and Miocene to Pliocene, which finding still applies in the main.

In the year 1890, as a result of the examination of marine fossiliferous beds traversed by bores put down, respectively, at Dry Creek and at Croydon in the coastal plains near Adelaide, Tate announced the existence in that locality, at some depth beneath the surface, of a still younger marine series, which he provisionally referred to the Older Pliocene. With the stepping down of Tate's Miocene to Pliocene, the superior series met with in the above bores is now referred by Howchin to the Upper Pliocene.

Tate also recognised the existence of Pleistocene marine beds located above sea level in the South-East and at other points along the coast and in the vicinity of Port Adelaide.

Until recently, literature dealing with the Tertiary limestones of South Australia, whilst accepting as Miocene and Pliocene the main formation observed, has had no regard for the existence of Oligocene marine beds, which age is now accepted for certain marine calcareous formations at the base of the type section at Blanche Point (Port Willunga), and for a similar horizon encountered in a recent bore at Knight's Dome, near Mount Gambier.

Howchin, in 1923, in a paper dealing with the formations exposed along a portion of the coastline of St. Vincent Gulf, relegated to the Oligocene a belt of sandy beds underlying the classic Miocene turritella beds of Blanche Point. Confirmation and extension of this finding has recently been supplied in a contribution dealing with the marine calcareous beds of that area by F. Chapman and Miss Irene Crespin. This and Chapman's finding of Oligocene marine and terrestrial beds below the Miocene near Mount Gambier, suggests that there is in all probability a widespread development of these beds at the base of the marine Tertiary of South Australia.

Present knowledge of these marine beds is obviously very far advanced, but this system still offers a rich field for further investigations. Until the several observers working on Australian marine Tertiary beds arrive at greater unanimity regarding the age of the several horizons represented, the position cannot be regarded as completely satisfactory.

### Tertiary Terrestrial Formations.

Passing now to the terrestrial beds of Tertiary Age, there is certainly a very important field open for investigation. In recent years Ward proposed the term Eyrian to signify an extensive series of Tertiary fresh water beds overlying a considerable part of the central artesian water basin. In places these beds are rich in fossil plant remains. At many other points in the State limited formations of a terrestrial nature have been encountered also carrying leaf impressions and fossil wood. Further, by systematic boring operations the Mines Department has in recent years proved the existence in this State of extensive areas of Tertiary terrestrial beds, rich in fossil plant remains and in places including considerable thicknesses of brown coal, similar to the Tertiary brown coals of Victoria. As these are known to underlie marine beds of Middle Miocene age, Chapman and I in 1920 suggested an early Miocene age for our South Australian brown coal formations. Now, however, the age must be put back to Oligocene, for I have found plant impressions of the same kind in terrestrial beds underlying the marine

Oligocene (Chapman and Crespin) at Maslin's Bay near Blanche Point. In this finding Chapman, who has examined and reported upon the plant impressions, is agreed.

It is, therefore, becoming more and more obvious that we have in this State a very extensive early Tertiary terrestrial record. This will provide geologists with a field for investigation for a long time to come.

## Glacial Phenomena.

### *LATE PALAEOZOIC GLACIATION.*

Now I come to one of the most enthralling features of South Australian strata, namely, the repeated occurrence therein of well authenticated evidence of past glaciation. In no country in the world perhaps are recurrent glacial periods better illustrated than in South Australia.

The first reference to past glacial action in the State dates from 1859. On that occasion Selwyn, then Government Geologist of Victoria, visited South Australia to report upon the geological features and mining possibilities of certain areas. When passing through the Inman Valley he noted a polished glacial pavement exposed in the bed of the Inman River at a spot where he happened to have made a halt. Though he definitely asserted that this was evidence of past glacial action, little general notice was taken of his report until many years afterwards.

Selwyn's report came under notice of Tenison-Woods, who, in his "Geological Observations in South Australia" in 1862, enumerated further evidence which he believed indicated past glacial action; but subsequent investigations have not substantiated Tenison-Woods' assertions.

On May 7, 1877, Professor Tate announced his discovery of a glaciated pavement along the edge of the sea cliffs at Hallett's Cove. Though he subsequently notified this discovery in several publications, little attention was paid to his finding until about 10 years later, when it was confirmed by other geologists and acclaimed as an outstanding discovery. From this date onwards Australian geologists became thoroughly glacially-minded. Reports of phenomena indicating past glacial action in several other States were thereafter published in quick succession.

Tate assumed that his Hallett's Cove discovery was evidence of a Pleistocene glaciation, such as he was well acquainted with in its occurrence in Europe. Later (1894) a committee of investigation, appointed by the Australasian Association for the Advancement of Science, proved the polished pavement to be pre-Miocene, and it was then immediately linked up with Selwyn's discovery in the Inman River Valley and assumed to correspond with the discovery of glacial evidence of Permo-Carboniferous age at Bacchus Marsh, Victoria. By that time also glacial horizons (ice-transported erratics) had been established in the Permo-Carboniferous marine beds of the Sydney-Newcastle coal basin.

In more recent years Howchin has done much to increase and consolidate our knowledge relating to the glacial formations of this age in South Australia, and has mapped extensive formations of the kind in the Inman Valley and neighbouring regions.

In Sir Edgeworth David's recently-published Geological Map of Australia, the Hallett's Cove and allied glacial beds of southern South Australia have been relegated to a late stage in the Carboniferous period, but there seems no valid reason why they may not be considered as late as early Permian in age.

## *LATE PRE-CAMBRIAN GLACIATION.*

In 1885 H. P. Woodward, then attached to the Geological Survey of South Australia, in a report on "The Geology of Country East of Farina," when describing a supposedly older Palaeozoic rock formation in the northern Flinders Range, remarks: "Towards the north-east end of the range these beds gradually change their lithological characters into a conglomerate, with boulders from several tons in weight to small pebbles of quartzite, sandstone, granite, limestone, marble and slate, scattered through a slaty matrix, of which there are large patches, without any boulders or pebbles. These beds, from their resemblance to boulder-clay, have most probably been formed in a similar manner, *viz.*, by floating ice dropping boulders and pebbles on to clay beds in process of formation."

These remarks constitute the first suggestion of glacial features in South Australian strata older than the Hallett's Cove beds.

Howchin, in 1901, after mature consideration of boulder-bearing beds exposed in the Sturt Creek near Adelaide, made a very important announcement that they represented glacial morainic debris at least as old as the Cambrian This discovery was received throughout the world with great interest. For many years, subsequently, he continued to follow up this discovery. Eventually, mainly as a result of his own observation, evidences of this glaciation were traced over a large part of the State.

In particular, Howchin followed it to the north end of the Flinders Range, joining up his discovery with that of Woodward and proving that Woodward's earlier discovery is also of Sturtian age.

For long the period of this glacial horizon was regarded as Lower Cambrian, but as the tillite on the Sturt Creek underlies the Brighton Limestone it is part of the Adelaide Series and consequently is now thought to be of late Proterozoic age.

## *CRETACEOUS GLACIATION.*

Still another glacial horizon recorded in Cretaceous strata in this State has now been clearly demonstrated. The first evidence of this glaciation was observed in the year 1905. This appears in H. Y. L. Brown's "Report on Geological Exploration of the north-west," where under date of May 10, 1904, he records abundance of erratics, some very large, resting on soft Cretaceous shale and silt on the plains near Stuart's Creek Station, located between Lakes Torrens and Eyre. Though he was convinced that they were ice-borne erratics, he assumed that they had been transported there by ice "at some time since the Mesozoic period." Dr. Ward reported the occurrence of erratic boulders associated with Cretaceous marine strata in that region, and further to the west in the year 1912 and on several occasions thereafter.

David, White and Howchin, in 1921, met an ice-scratched erratic lying on the surface of Cretaceous beds north of Oodnadatta. Later, in 1924, Dr. Woolnough reported what appeared to be erratics in Cretaceous beds at Moolawatana Station at the northern tip of the Flinders Range.

A convincing summary of the evidence for a Cretaceous glacial horizon near the base of the marine Cretaceous beds of the Great Artesian Basin is supplied by Dr. R. L. Jack at the meeting of the A.N.Z.A.A.S. in 1932 (p. 461). The evidence indicates that floating ice transported erratics in the Cretaceous sea of that time.

### Profound Climatic Changes in South Australia in the Pleistocene Coincident with Glaciation Elsewhere.

There is no evidence of glaciation in South Australia during the Pleistocene period, a time when large areas of other lands were overwhelmed with ice.

Evidently South Australia, taking into consideration its latitude, was not sufficiently elevated to favour permanent accumulations of ice such as are known to have formed on the more elevated portions of the Australian Alps in the neighbourhood of Mount Kosciusko. But there is ample evidence of a remarkable change in the climate of Central Australia during that period of world-wide glaciation. Aridity, which appears to have usually prevailed in Central Australia during the ages, was then dispelled and it became, for a time at least during the Pleistocene, a moderately well-watered region. Tate was one of the first to draw attention to evidences supporting this contention. In one place Tate remarks "a vastly increased rainfall over what is now the arid region of Australia during the Diprotodon Period is demanded by the extinct rivers, circumscribed lacustrine basins marked by their coincident sand beaches, and the remains of large herbivores, whilst the lacustrine origin of the low level deposits is indicated by the presence of crocodiles, turtles and fish."

Howchin, in recent years, has written much on the "dead rivers" to which reference has just been made.

David, in his "Explanatory Notes" accompanying his recent geological map of Australia, elaborates this lake period of the Pleistocene.

Some of us have observed old wave-cut terraces of one-time Greater-Lake Frome and Greater-Lake Eyre. There is no doubt that extensive fresh water lakes did exist in the interior during the period of the Pleistocene Ice Age, and these must have received annual increments of sediment, in proportion related to the annual variations in climate and probably, for a time at least, rhythmically affected by winter snowfall and summer thaw. There is, therefore, good prospect of climatic variations during our Pleistocene being recorded in the sediments of our lakes. Perhaps it may some day be possible to test the nature of such deposits by boring into the Pleistocene deposits in the basin of Lake Eyre.

### The Changing Level of the Sea during the Pleistocene Ice Age.

Further, there is still ample scope for detailed investigation of the Pleistocene history of the South-Eastern region of the State. That great flat region must have offered exceptional opportunities for recording negative and positive movements of the sea during and after the Pleistocene Ice Age. Such movements of the sea following the ice loading and unloading of polar lands may account for recurrent old shore lines marked by the dune ridges of the South-East.

### Tectonic Movements and Physiographic Relief.

Another phase of geological research in South Australia undertaken during more recent times is that relating to diastrophic movement resulting in the present outstanding topographical features. Dr. Benson was one of the first to take a notable interest in such work. In the year 1908, in order to illustrate his views on the block-elevation of the Mount Lofty Ranges, he constructed a plaster model illustrating their topographical features and drawing attention to the raised peneplain. Howchin continued these studies and developed the subject in more detail and in reference to the whole State. Finally, Dr. Fenner has completed the study in elaborate detail.

### The Igneous Rocks.

With regard to the igneous rocks of South Australia, a brief review of the progress achieved in relation to these was published in 1926 (Mawson, A.A.A.S., p. 230). Since then several important contributions to the subject have appeared in the volumes of this Society.

# NOTES ON THE GEOLOGICAL SECTIONS OBTAINED BY SEVERAL BORINGS SITUATED ON THE PLAINS BETWEEN ADELAIDE AND GULF ST. VINCENT.
# PART II-COWANDILLA (GOVERNMENT) BORE.

*BY PROFESSOR WALTER HOWCHIN, F.G.S.*

**Summary**

The notes already published in the present series have included the borings at Hilton, Black Forest, Brooklyn Park, and Glanville [Howchin, W., 19351. The present paper offers observations of a similar kind with reference to a boring at Cowandilla.

It must be understood that the palaeontological descriptions (as was stated in Part I) are not exhaustive. Other borings in the same prolific and interesting geological field await examination and time is a pressing question with the author, but it is hoped that these preliminary sketches will contribute towards the comprehensive studies of the Tertiary faunas of southern Australia. As stated in Part I, Mr. B. C. Cotton, of the South Australian Museum, rendered the author valuable assistance in the determination of certain species.

# NOTES ON THE GEOLOGICAL SECTIONS OBTAINED BY SEVERAL BORINGS SITUATED ON THE PLAINS BETWEEN ADELAIDE AND GULF ST. VINCENT.

## PART II—COWANDILLA (GOVERNMENT) BORE.

By PROFESSOR WALTER HOWCHIN, F.G.S.

*Also an Appendix in which the Author and Bernard C. Cotton, conjointly, describe a New Gasteropod.*

[Read April 9, 1936]

PLATE I.

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## I—INTRODUCTORY REMARKS.

The notes already published in the present series have included the borings at Hilton, Black Forest, Brooklyn Park, and Glanville [Howchin, W., 1935]. The present paper offers observations of a similar kind with reference to a boring at Cowandilla.

It must be understood that the palaeontological descriptions (as was stated in Part I) are not exhaustive. Other borings in the same prolific and interesting geological field await examination and time is a pressing question with the author, but it is hoped that these preliminary sketches will contribute towards the comprehensive studies of the Tertiary faunas of southern Australia. As stated in Part I, Mr. B. C. Cotton, of the South Australian Museum, rendered the author valuable assistance in the determination of certain species.

With reference to the present bore: in the first instance, a large quantity of the material was forwarded to the author from the richly fossiliferous zone included within the 485 feet to 507 feet levels, on which attention was at once directed. In some way the rest of the samples from the bore appear to have gone astray, and it was feared that the parcel mentioned would be the only part of the bore material available for description, and was, therefore, dealt with from that standpoint. At a later stage some of the missing parcels were recovered, which completed the samples from the surface to a depth of 550 feet, still leav-

ing a blank from the latter level to a depth of 670 feet, at which stage the boring was stopped.

It will be noticed that in the present bore the fossils catalogued are considerably in excess of those recorded from any of the other bores dealt with in the present series. It does not follow that the Cowandilla sediments are relatively richer in their fossil contents than the others, but the material available was much larger in quantity than in the case of any of the others, and permitted a greater expenditure of time and effort in obtaining the palaeontological results.

The 470-485-feet sample (which was taken from the upper limits of the richly fossiliferous zone that continued to the 508-feet level) did not come to hand until the notes on the latter had been completed, so that in the examination of the supplementary sample at a higher level only such species were recorded as had not been previously noted, or these were only briefly referred to.

The Cowandilla bore is situated in the north-western corner of Section No. 92, Hundred of Adelaide, at the corner of Plympton Road and Hounslow Avenue.

## II—STRATIGRAPHICAL AND PALAEONTOLOGICAL DESCRIPTIONS.

### 1. Non-fossiliferous Fluviatile Deposits.

**Depth, 1-38 ft.**—Three samples were washed and examined within these limits. The prevailing feature is a yellowish clay, more or less sandy with occasional small pebbles. Beds of loose argillaceous sands occur at the respective depths of 12 feet and 38 feet. The sand is very fine and sharp and carries spangles of mica. Between the 12 and 36-feet levels is a well-defined gravel-bed with pebbles of white quartz and some quartzites up to two inches in diameter. Two examples are of honey-combed (vein) quartz, and one pebble of milky-quartz carries inclusions of black, fibrous tourmaline, a common type of rock that occurs in the Pre-Cambrian beds of the River Torrens gorge.

**Depth, 36-45 ft.**—Coarse to fine grit, held together by a darkish yellow clay. The bed carries a few small rounded pebbles of quartz and quartzite, but otherwise consists of angular and sharp fragments that show little evidence of wear.

**Depth, 45-81 ft.**—Similar to the last-named but limited to the smaller grade material and mixed with more clay.

**Depth, 81-101 ft.**—Quartz and quartzite gravel, mixed with coarse, sharp grit and fine sand with some yellow clay.

**Depth, 94-100 ft.**—Clear, fine, uniform, yellowish quartz sand, the larger grains rounded, the smaller, sharp.

**Depth, 101-148 ft.**—Yellow clay and sharp sand, more clay than sand.

**Depth, 148-171 ft.**—Coarse and fine sharp grit, held together by clay.

**Depth, 171-189 ft.** Variegated clays with fine sharp sand.

**Depth, 189-216 ft.**—Yellowish sandy-clay, excessively fine-grained with minute flakes of mica.

**Depth, 216-218 ft.**—Yellow clay and fine, sharp sand.

**Depth, 218-236 ft.**—Similar to the preceding.

**Depth, 236-278 ft.**—Ditto, with small pellets of ferruginously-hardened clay.

**Depth, 278-283 ft.**—Reddish clay with sharp sand, of medium grade; a few ferruginous pellets, as in the last sample; vegetable tissue much iron-stained.

**Depth, 283-304 ft.**—Reddish incoherent sand, fine to coarse.

**Depth, 304-370 ft.**—Lighter-coloured clay with high proportion of coarse and fine sand. Many of the larger granules are a light-coloured quartzite, like the whitish felspathoid quartzite of the basal beds, Mount Lofty.

**Depth, 370-383 ft.**—Drab-coloured clay with high proportion of quartz sand; larger grains well-rounded, the rest sharp.

**Depth, 383-385 ft. 9 in.**—Rather light-coloured material—probably taking their appearance from the milky-coloured quartz sand which is present in considerable quantity. A few small pellets of carbonate of lime, in the form of calcareous tufa, forming a cement in the aggregation of sand grains. No organic remains.

**Depth, 385 ft. 9 in.-386 ft.**—This sample consisted simply of two very compact, solid lumps of calcareous sandstone. Tested by HCl. the stone is a uniform, excessively fine quartz sand, closely packed and cemented by a film of carbonate of lime. No organic remains can be recognised in it. According to the workman's log the layer is limited to a thickness of three inches and may be only a casual rock fragment.

## 2. Adelaidean (Upper Pliocene).

**Depth, 386-408 ft.**—Three kinds of rock were present in the sample. Two pieces represented a calcareous sandstone, somewhat similar to the last described; there were also several lumps of a whitish tufaceous limestone, of an open texture, that could only be formed under dry conditions; while the balance is a dark, bluish, argillaceous limestone in small pieces, that goes down completely when treated with HCl, leaving a residue of very fine sand and a black sediment of carbonaceous mud. This limestone was not met with again at other depths.

It was at the present levels that organic remains made their first appearance. A few fragments of pelecypod shells were seen sticking in the limestone. The only powdery material was what could be got by washing the rocky samples present, and from this source were obtained, broken spatangoid spines, two small imperfect gasteropods, about half the test of the flat echinoderm, *Laganum platymodes* Tate and the following foraminifera:—

*Quinqueloculina seminulum* d'Orb.
*Triloculina trigonula* Lamk., *T. tricarinata* d'Orb.
*Clavulina parisiensis* d'Orb.
*Cribrobulimina mixta* (syn. *polystoma)* P. and J. sp.
*Sigmoidella elegantissima* P. and J.
*Guttulina problema* d'Orb.
*Cibicides lobatulus* (W. and J.).
*Discorbis turbo* (d'Orb.).
*Epistomella polystomelloides* (P. and J.).
*Rotalia beccarii* Linn. *R. howchini* Chap., Parr and Coll.
*Elphidium* (?) *macellum* (F. and M.).

The last-named species is an unusual variety. Its depressed form and sharp periphery are characteristic of the species named, but is usually of larger dimensions [2 mm.], develops a marked umbilical prominence of clear shell substance, and about twice the number of segments that are characteristic of the typical *E. macellum*, and in these respects resemble *E. craticulatum* (F. and M.). It may be taken as an annectant of the two species, or, otherwise, a new species.

**Depth, Uncertain.**—All the larger lumps, up to one inch in length, consist of light-coloured tufaceous limestone of open texture. The organic remains observed were a few small gasteropods, broken echinid spines, one frag-

ment of a ribbed *Dentalium*, a single valve of a much-weathered *Venericardia compacta*, the valve of an ostracod, and a few foraminifera of the same species as last described. A lump of the white, tufaceous limestone, treated with HCl, left a considerable residue of dark-coloured flocculent mud and very fine sand.

**Depth, 410 feet.**—The sample formed part of a core cut by a six-inch revolving boring tool and showed a junction between overlying red clay and a lower bluish clay-silt. The coarser material (apart from two small rounded pebbles of quartzite) consisted of shell fragments, amongst which could be recognised remains of Pectenidae, greatly discoloured; no complete valve of a pelecypod and no gasteropod. The only determinable organic remains were foraminifera, and these were in a very weathered condition, generally blackened and often broken. The sediments are suggestive of a mixed origin—fluviatile deposits laid down on a marine floor by a change of physical conditions.

**Depth, 414 ft.** A dark-coloured calcareous silt in hard lumps. Portion of a valve of *Chlamys asperrimus* sub. sp. *antiaustralis* (Tate) was firmly attahed to one of the latter; very thick portions of the tests of *Miltha (Milthoidea) grandis* (H. Woods) were firmly embedded in some of the lumps. Only a small amount of the soft and loose portion of the bedding was available for examination, and in this the microzoa were scarce.

**Depth, 420 ft.**—Darkish grey calcareous silt with a high proportion of very fine sand; in consolidated lumps when dry. Fossils scarce and chiefly limited to the foraminifera, of which the following species were obtained:—

*Triloculina trigonula* Lamk., *T. tricarinata* d'Orb.

*Quinqueloculina venusta* Karrer.

*Spiroloculina* aff. *arenaria* Br. This is a very remarkable object in the present fauna. It is relatively large, measuring 1·8 mm. in length, and resembles the above species, in some respects, but differs in others. Brady's figure shows the test to have a uniform rather fine sandy surface. The present species is built up of coarse material in which clear or white quartz is the normal mineral used, set plumb with the surface, in a white lime-like matrix. Scattered over the surface, and, usually, rising slightly above the normal level, are a number (varying from about 12 to 20, or even more) of black, shining granules, mostly more or less rounded but sometimes angular. These black, bead-like grains set in the test at intervals, make a remarkable feature in contrast with the white background, forming a speckled object. The species is persistent through a considerable thickness of strata and will be referred to again.

*Cribrobulimina mixta* (syn. *polystoma)* P. and J. sp.

*Guttulina problema* d'Orb.

*Discorbis turbo* (Br.).

*Rotalia beccarii* Linn. *R. howchini* Chap. Parr and Coll.

*Elphidium* (?) *macellum* (F. and M.).

*Marginopora vertebralis* (Quoy and Gay), a fragment.

Casual specimens include tuberculated plates and spines of echinids, an ostracod valve, and the otolith of a fish. All the remains are much weathered and many are imperfect.

**Depth, 430 ft.**—A six-inch core of bluish clay similar to the preceding. The coarser residue left by the washing consisted of the harder and unreduced portions of the bedding with a considerable number of small angular fragments of pelecypod shells. Some of the latter have formed part of thick tests, probably from the shells of *Miltha (Milthoidea) grandis* (H. Woods); a single valve of the Recent, *Nucula obliqua* Lamk., and a fragment of *Dentalium intercalatum*

*francisensis* Verco. The foraminifera include most of those mentioned as occurring in the preceding sample, with the additions, *Quinqueloculina seminulum* d'Orb. and *Sigmoidella kagaensis* Cush. and Oz. All the remains are greatly weathered.

**Depth, 440 ft.**—Small pieces of the bedding, as nodules, not much larger than peas, form the coarser material, and are speckled with white flakes of shelly matter, which have helped to cement the matrix into nodules. Except fragments of certain pelecypod shells, chiefly broken down Pectenidae and probably *Miltha grandis,* and one small example of *Cylichnella callosa* Tate and Cos., the fossil remains were limited to microzoa, of which the foraminifera formed the principal feature. The species are mainly those previously mentioned. *Elphidium* (?) *macellum* and *Rotalia howchini* are particularly numerous, large, and well preserved; others worthy of mention are *Discorbis turbo, Cibicides lobatulus, Guttulina problema,* and *Cribrobulimina mixta* (syn. *polystoma).*

**Depth, 448 ft.**—Part of a six-inch core, consisting of a compact slate-coloured clay with a high proportion of fine, sharp sand. No fossils visible in the mass, which washes down easily. Residue, after washing, consisted of pellets of the bedding, slightly calcareous; mollusca represented only by small, flaky fragments; foraminifera similar in species to the preceding and with about the same frequency, most of the latter are discoloured, some quite black.

**Depth, 458 ft.**—Similar to the preceding, consisting of an argillaceous silt with a high proportion of very fine sand. No fossils were visibly present, and the larger particles, after washing (seldom exceeding 5 mm. in diameter), were shell fragments, mostly angular; polyzoal remains, a little more common; and foraminifera, as previously noted, but in rather fewer numbers.

**Depth, 465 ft.**—A slate-coloured, uniform silt, defectively coherent; no fossils visible in the mass, goes down easily and is much reduced by washing, the residue chiefly a very fine siliceous sand. Shell fragments small and not numerous. The only pelecypods sufficiently preserved for definition were, a very small valve of *Glycymeris* sp., only 2 mm. in diameter, and a small, imperfect *Leda* sp.; a few small gasteropods, mostly broken, and fragments of polyzoa. The foraminifera are abundant but restricted to few species, including *Quinqueloculina seminulum* d'Orb., *Clavulina angularis* d'Orb., *Marginulina costata* Batsch, *Guttulina regina* (Br. P. and J.), and *G. problema* d'Orb.

**Depth, 470 ft.**—Material similar to the last described. Weight of sample in the rough, when perfectly dry, 21 oz.; when washed and dried, 9 oz. of very fine quartz sand. The coarser siftings contained objects up to 5 mm. in length and consisted almost entirely of shell fragments, which were angular and sharp. As the core was delivered in its original shape this brecciated condition could not have been caused by drill-percussion but from some natural causes, probably those of transport. Other fossil remains, very scarce. In the very small material two minute Recent shells were obtained, namely, *Leda* (sub-gen. *Scaeoleda) verconis* Tate and *Cylichnina pygmaea* (A. Ad.). The foraminifera are the most important fossiliferous features, *Rotalia beccarii* and *R. howchini* Chap., Parr and Coll., are the most prevalent forms; others are, *Spiroloculina* aff. *arenaria* Br., *Cribrobulimina mixta* (syn. *polystoma),* and *Marginopora vertebralis* Q. and G.; one of the latter a nearly complete disc, and others in thick fragments from complex forms. In addition, a few common kinds of microzoa and otoliths of fishes.

*The Section, next following, from 470 feet to 507 feet, commonly spoken of as "The Oyster Bed," comprises the chief fossil-bearing Zone of the Bore.*

**Depth, 470-485 ft.**—Up to and including the last sample under examination (with the exception of one or two almost microscopic shells) no complete valve of a pelecypod had been met with in the borings. At about the 470-feet level a complete change occurred. Within the vertical limits now under description very large molluscan shells and other marine objects make a sudden appearance, and many of them in an excellent state of preservation. These were evidently individually selected from the bore material, as the bag containing them had little of the matrix present, and were intended as the first fruits of the rich harvest that was to follow. By an oversight, the succeeding sample, representing the 485-508-feet levels, was forwarded first, and in the absence of any further samples was investigated and the fossils described before the preceding 470-485-feet sample came to hand. This explanation is necessary, as many of the species in the present sample had been described in M.S., under the next heading, before the present sample was received, and, therefore, the latter requires only a brief notice here. The smaller objects were obtaind by washing down the matrix that was attached to the larger fossils.

## PROTOZOA.

### Foraminifera.

The following species have not been previously observed in this bore, or recorded in the next following sample:—

*Pyrgo elongata* d'Orb. A single imperfect example.

*Triloculina linnaeana* d'Orb. Has strong longitudinal ribs or costae.

*Triloculina circularis* Bornem. An anomalous form with irregularly disposed chambers, large aperture and wide tooth.

*Epistomella polystomelloides* (P. and J.).—The occurrence of this somewhat rare species in the present bore is of some interest. It was first described by Parker and Jones as "from the Australian coral reefs (Jukes Dredgings),"* and named *Discorbina polystomelloides;* defined, as "large, symmetrical, extremely rough, the chinks between the chambers partly bridged over so as to form a rough canal system as in some of the Polystomellidae." Brady ("Challenger" Report) records it from three stations south of New Guinea. Heron-Allen and Earland obtained it from the Kerimba Archipelago, Portuguese East Africa [H. and E., 1915]. The same authors [1911] also obtained it from the shore-sands of Selsey Bill, Sussex, as a supposed derived Tertiary fossil and state: "We have no knowledge of any previous occurrence as a fossil." The authors quoted evidently had overlooked my record of the species from the Lower and Upper beds at Muddy Creek over 30 years previously [Howchin, W., 1888]. We have, in the Cowandilla bore, yet another instance of its occurrence, in which it is sparingly represented. The specific features are so strongly marked it cannot be mistaken.

## MOLLUSCA.

### Pelecypoda.

*Cucullaea corioensis* McCoy. Two examples, rather below medium size.

*Glycymeris convexa* (Tate). A single valve.

*Pinctada (Margaritifera) carchariarum* Jameson. One valve that includes most of the hinge plate and 85 mm. in the dorsal-ventral measurement.

*Ostrea hyotidoidea* Tate. Four practically complete valves.

*Chlamys polymorphoides* Zittel. One valve.

*Chlamys asperrimus* subsp. *antiaustralis* (Tate). One example.

*Eucrassatella kingicoloides* (Pritchard). Two right-hand valves, each imperfect on the posterior side.

*Miltha (Milthoidea) grandis* (H. Woods). A practically perfect right valve; length, 84 mm.; width, 74 mm.; also imperfect right and left valves.

*Meretrix sphericula* Tate and Basedow. A perfect example, with the two valves in position and filled with the original silt of the bedding; also many fragments of shells belonging to other examples of the same species.

*Antigona* (?) *dimorphophylla* (Tate). Part of a single valve, lacking the dorsal portion—must have been of very large size.

### Gasteropoda.

*Neodiastoma provisi* (Tate). Two examples that show variant features.
*Pelicaria howchini* B. C. Cotton. Three examples.
*Siliquaria australis* Q. and G. Several short broken lengths.

### Promiscuous Remains.

Echinodermata. Spines, mostly Spatangoids.
Ostracoda. As single valves.
Polyzoa. Common in small pieces.
Fish Remains. A small sharp-pointed teleostean tooth, otoliths, coprolites, and numerous black-coloured pellets and flakes as undeterminable fish remains.

**Depth, 485-507 ft.**—This, with the preceding sample [470-485 ft.], forms the chief source from which the fossils of the bore have been obtained. The matrix is a fine, sandy, greyish silt, with fine sand in excess. The bed is incoherent in mass. After separating the coarser shell material—whole and broken—by sieves, the finer material was passed through sieves of successive fineness from which the smaller objects could be selected.

The following is a list of the fossils at present determined at this particular depth:—

## PROTOZOA.

### Foraminifera.

*Triloculina trigonula* Lamk. A form more characteristic of temperate than tropical seas, in shallow water. Present in Australia at most Tertiary horizons.

*Triloculina tricarinata* d'Orb. A cosmopolitan species, attains greater depth than the preceding. A common Tertiary fossil.

*Triloculina oblonga* Mont. Found at all depths, but most at home in shallow temperate seas. Dates from the Eocene.

*Spiroloculina* aff. *arenaria* Br. This is the black and white speckled form described under the 420-feet horizon.

*Quinqueloculina polyana* d'Orb. This form belongs to the quinqueloculine group that is characterised by a rounded periphery and costate, or striate, sculpture. The test is elongated and carries rather fine and numerous costae. It differs from *Q. costata* d'Orb. in its relatively narrow and elongated outline, and has not the produced apertural end that is often present in the latter. It is a common form in the shore lands of the West Indies; noted by d'Orbigny ("Cuba"); also Cushman ("Atlantic Ocean"). It is recorded by some authors under *Miliolina bicornis* W. and J.

*Quinqueloculina* aff. *ferussacii* d'Orb. One example, d'Orbigny's "modèle," illustrating this species, shows a narrow form, multiangulated, in transverse section, and with a produced neck. The Cowandilla example is an elongated-oval in outline, angulated, and without a produced neck; agreeing with such examples as figured by Parker and Jones ("Foram. of the North Atlantic and Arctic Oceans," pl. xv, fig. 36) and Sherborn and Chapman ("Foram. of London Clay,"

pl. xiv, fig. 5). The "Challenger" Expedition obtained it only from two or three dredgings off the Australian coast. It is a common fossil in the Tertiary beds of Europe, and has a considerable vertical range of beds of the same age in Australia.

*Cribrobulimina mixta* (syn. *polystoma)* P. and J. sp. This is an interesting local species. It was first figured by Parker and Jones, in Carpenter's "Introduction" without description, but showing two kinds of aperture, which are classed as varieties of *Valvulina triangularis* d'Orb. In 1864 (1865) the same authors in a paper published in "The Philosophical Transactions, Royal Society," on "Some Foraminifera from the North Atlantic and Arctic Oceans," included some "Miscellaneous Lists," one of which (Col., No. 30) was stated to be from Melbourne, Australia, and by a foot-note affixed the name *Valvulina mixta* to the figure that had been previously published by them in Carpenter's "Introduction." At the same time they added another name, *V. polystoma*, for a supposed related species, also without description. It is probable that the authors intended to give specific distinction based on the two kinds of aperture. Neither C. D. Sherborn, in his "Index" (1893), or J. A. Cushman, in his "Foraminifera" (1928), accepted the second name, but recognised *mixta* P. and J. as of specific value. Moreover, Cushman [1928, p. 129] substituted the generic name, *Cribrobulimina* for *Valvulina*, and regarded the difference of aperture in individuals a matter of age, a simple valve-like opening in youth, and in the adult a series of small openings forming a cribrate plate. Over 50 years ago the writer obtained from the shore sand of Gulf St. Vincent examples of both kinds. Subsequently, Mr. W. J. Parr collected specimens from the same locality [Parr, W. J., 1932 (a), p. 6]. Parr considers that P. and J.'s list (mentioned above) really came from South Australia and not from Melbourne, as stated by these authors [in the early days Melbourne and South Australia were commonly regarded as one and the same locality], and states: "Two of the species listed, *Valvulina polystoma* and *V. mixta*, have not occurred in any of my material from Victoria, while others mentioned are much commoner in South Australian waters." Parr also suggests that *C. mixta* represents the megalospheric, and *C. polystoma* the microspheric, form of the species. The only known fossil occurrences for this form are the older raised sea beach (Pleistocene) of South Australia and the Upper Pliocene of the Adelaide faulted basin.

*Clavulina parisiensis* d'Orb. Five examples were obtained. Test, finely arenaceous; triserial part forms the greater portion; aperture circular with tooth. First recognised in Eocene of Paris and London. Occurs in Sorrento bore (Vict.). Recent; sparingly in all the main oceans.

*Marginulina costata* (Batsch). One large and perfect specimen. As a Recent form, mostly limited to the North and South Atlantic and Mediterranean; as a fossil, it dates from the Mesozoic; Australian—Cretaceous: Hergott and Tarkaninna; Miocene: Muddy Creek, Murray Plains and Sorrento bore.

*Sigmoidella elegantissima* (P. and J.). Before Cushman and Ozawa undertook the reclassification of the Polymorphinidae the present species was included in the genus *Polymorphina*. The latter has now a very restricted range and has given place to several new genera, subgenera, and species. *S. elegantissima* is, typically, Australian in its distribution in Recent seas, and has been recorded from most of the Tertiary horizons in Victoria and from the Lower Pliocene of South Australia.

*Sigmoidella kagaensis* Cush. and Oz. Similar to *S. elegantissima* but is more elongated, the sides more or less parallel for some distance.

*Guttulina yabei* Cushman and Ozawa. Rather scarce. This is considered by the authors to be the same form that Brady ("Challenger" Foram. lxxiii,

figs. 2, 3) erroneously referred to *Polymorphina oblonga* d'Orb., and consequently renamed it as above. (C. and O., 1930, p. 30.) The test is elongated with inflated, almost spherical chambers, with depressed sutures, somewhat resembling a small bunch of grapes. Brady's specimens were from the Australian region, and C. and O.'s, off Japan. The Cowandilla specimens resemble closely the type illustrated.

*Guttulina problema* d'Orb. Rather scarce. Brady united *Polymorphina problema* and *P. communis* d'Orb. under a single species. Cushman and Ozawa have done the same, with a long synonymic list. The test is short and somewhat broadly fusiform in outline, chambers slightly elongated and inflated, arranged in a clockwise order. It is a widely distributed form in existing seas. Dates from the Cretaceous and is particularly common in the Tertiary formation of many lands, including Australia.

*Discorbis turbo* (d'Orb.). Moderately common. A well-differentiated species, with a smooth, conical, dorsal surface, faintly impressed sutural lines, and rather coarse perforations. Dates from the chalk, and is a common species in the Eocene of the Paris basin. It is widely distributed in existing seas, reported from two dredgings, in the "Challenger" cruise, off the coast of New South Wales; a frequent species in the Tertiaries of Victoria and South Australia.

*Cibicides lobatulus* (W. and J.). Two examples. This species has the parasitic habit of attaching itself to algae and other objects and reverses the usual order in that the dorsal side, which is, usually, the upper and convex face, is, in this species, the under side flattened as the side of attachment; while the ventral side forms the upper and convex surface. It is subject to considerable variation. It is almost of cosmopolitan distribution, especially in the cooler seas, and is equally plentiful in a fossil condition—there are few Tertiary horizons in which it does not occur.

*Rotalia beccarii* Linné. This is, by far, the most abundant species in the present material, and include examples of all ages and sizes up to unusually large specimens. It is, characteristically, a shallow water species and favours temperate seas. It is also one of the commonest middle and later Tertiary fossils in most lands where these beds occur, including Australia.

*Rotalia howchini* Chap., Parr, and Collins. This species was described by myself as a variety of *R. clathrata*, obtained from both the lower and upper beds of Muddy Creek [Howchin, W., 1889, p. 15]; also from the bore at Lilydale sheep station [Howchin, W., 1915, p. 350]. The above authors considered it to be worthy of specific rank, as given above [Chap., Parr and Collins, 1934, p. 566]. It is quite common in the present sample of material, and seems to have a much wider distribution in the Australian Tertiaries.

*Elphidium striatopunctatum* (F. and M.). Rare. This species is the weakest modification of the genus. It has few chambers, and the examples in the present material illustrate the range of variation usually seen in the species; some of which have the septal lines marked by simple punctures; while in others, septal bridges of small size are developed. A cosmopolitan species, mostly with a shallow-water habit, and is sometimes found as small and weakly-developed examples in estuaries. It lives in the Port Adelaide River. A common Tertiary species at most horizons.

*Elphidium macellum* (F. and M.). Rather scarce. [See *ante*, p. 3.] A comparatively, shallow-water species. Occurs in the Port Adelaide River (Howchin) and is a common form in the Australian Tertiaries. Chapman records it in the Sorrento bore at five horizons, ranging from 476 feet to 1,320 feet.

*Elphidium crispum* Linn. A few examples agreeing with the specific features and with similar geographical and geological occurrences as the preceding.

*Elphidium craticulatum* (F. and M.). Three good examples. This is the largest and most highly developed species of the genus. The test is thick with very numerous septal bands and the umbilicus shows a considerable development of clear shell substance that has an even surface with the rest of the test. It is more tropical in its distribution than the other members of the genus—according to the "Challenger" Report, "from the Levant, southwards, to the shores of Australia." The same Report says, "It is not known as a fossil species." The Australian geological observations came as a subsequent discovery. The species occurs at Muddy Creek, and in the Sorrento bore at a depth of 1,060 feet. It is interesting to find it in the Upper Pliocene beds near Adelaide, a further evidence of the warmer conditions that formerly prevailed in these latitudes.

## MOLLUSCA.

### Pelecyopoda.

*Leda apiculata* Tate. Inflated, acuminately rostrated, whole surface marked by concentric raised threads. Length of largest specimen, 11·2 mm.; height, 6·5 mm.; eight smaller examples were obtained. Very common in Turritella clays at Blanche Point, Aldinga; also in Adelaide bore, and at Muddy Creek and Schnapper Point (Vic.).

*Arca pseudonavicularis* Tate. Two valves, right and left. Other occurrences, Adelaide bore and Table Cape.

*Arca (Barbatia)* sp. indet. Portion of a right valve, 50 mm. in length, incomplete on the ventral and posterior margins. The posterior portion of another example was obtained.

*Cucullaea corioensis* McCoy. In a previous paper [Howchin, W., 1935, pp. 85, 89] reference was made to the very large examples that occur in the Adelaidean Upper Pliocene. Three very large and thick-shelled fragments of the above species were obtained from the present boring, limited to the ventral portions of the shells, the largest having a length of about 90 mm.; a few ephebic examples that were also present show the complete valve.

*Cucullaea corioensis* McCoy, var. (undetermined). A single left valve was obtained that shows the general outline of the type, with a length of 76 mm. and breadth of 65 mm., but differs from the species inasmuch as the growth lines are strongly marked in variable concentric laminae, the radial lines are limited to, and only faintly indicated on the anterior side; the shell, as a whole, showing a relatively smooth surface. The ventral edge, on its inner margin, is very strongly crenulated with prominent narrow ridges that increase in length to 10 mm. towards the posterior angle; vertical teeth obsolete, lateral teeth imperfectly developed and lamellose.

*Cucullaea adelaidensis* Tate. Two valves were obtained that apparently belong to this species. One, a nearly perfect left valve, accords with Tate's type in its size, degree of obliquity, and fineness of radial sculpture; also, a somewhat less complete right valve of corresponding size, and having fewer and rather broader riblets than on the left valve, a peculiarity in this species that has been pointed out by Singleton [1932, p. 304].

As an Australian Tertiary genus *Cucullaea* has its chief occurrences in Victoria, most characteristically in the Balcombian and Janjukian stages of the Miocene, and less so in the Kalimnan of the Lower Pliocene. The genus has a remarkable development, with very large examples in the Upper Pliocene (Adelaidean) of South Australia. *C. adelaidensis* has, hitherto, only been recorded from the Miocene beds of the Kent Town bore, near Adelaide, and is the only Miocene record for this genus in South Australia.

*Glycymeris convexa* (Tate). This is one of the commonest species of *Glycymeris* in the material. It is of medium size, high convexity, and has an average of 24 radial ridges that are narrower than the interspaces.

Occurrences:—Adelaidean (Up. Plioc.): More or less, at the same horizon, in all the bores in the faulted Adelaide basin. Kalimnan (Low. Plioc.); River Murray (Up. Ser.); Aldinga (Up. Ser.); Hallett's Cove (S. Aust.); Muddy Creek (Up. Ser.); Mallee bores (Vict.).

*Glycymeris flabellatus* (T. Woods). Among the glycymerids present, three examples were of outstanding size. The largest of these is slightly ovate and somewhat oblique in outline; has a length of 49 mm. and height of 50 mm.; has 23 radial costae that are broad and flattened and wider than the intervening spaces; the costae are crossed by numerous concentric lirae which are less defined in the intercostal spaces, the weathered condition of the test has probably softened some of the ornamental lines. The specimens have a close resemblance to the above species with some slight differences, the fossil examples being ancestral to those now living.

Occurrences:—Recent: Not common on the local beaches, but fairly common in moderately deep water. Adelaidean (Up. Plioc.): Cowandilla bore (S. Aust.). Werrikooian (Western Vict.).

*Glycymeris planiuscula* Chap. and Sing. This was a MS name by Tate that was utilized by Dennant in a list of fossils obtained from the Glenelg River (Vict.), 1887. The name was revived and the type specimens lodged in the National Museum, Melbourne, described by Chapman and Singleton [1925, p. 43]. The examples from the Cowandilla bore agree closely with the type. It is a graceful little shell. The straight dorsal line immediately attracts attention. A medium-sized specimen has a length of 13 mm. and a height of 11 mm., ornamented with 27 rounded, radial riblets separated by wider interspaces. In some cases the riblets, instead of being straight, are more or less curved towards the respective anterior and posterior margins. The riblets or costae are crossed "by fine thread-like lines of growth," in a regular order of two lines to a millimetre and each line is continuous throughout the whole length of the shell. In the specimens obtained from this material there is a great range in size, from neanic forms of 3 mm. in length up to a length of 23 mm. and height of 21 mm. In the larger specimens the concentric fine lines become thickened and more laminar, approaching the characteristics of *G. convexa*.

Occurrences:—Adelaidean (Up. Plioc.): Cowandilla bore (S. Aust.), common. Werrikooian: Glenelg River (Vict.). Kalimnan (Low. Plioc.): Grange Burn, Muddy Creek (Up. Ser.), and Mallee bore No. 6 (Vict.).

*Phylobrya*, sp. indeter. This small and somewhat peculiar shell is not a common genus in the Australian fauna, either Recent or fossil. In the present material it is represented by ten examples. The largest specimen has a length of 7 mm. and a height of 6·5 mm., subcircular and somewhat oblique in outline, inflated, umbos prominent and incurved; ornament, numerous rounded concentric costae crossed at right angles by radial costae; surface of valve divided into about four inflated growth folds, divided by deep sulci; ventral inner margin finely crenulated by nodular prominences, from which extend fine striations inwardly. One example of the same species was obtained from the Glanville bore, at 375-400 feet, but was overlooked at the time.

Occurrences:—Two living species are recorded from Southern Australia and Tasmania; one from the Newer Tertiary of New Zealand, and two from the Miocene of Victoria. With none of these can the Cowandilla examples be identified.

*Pinctada (Margaritifera) carchariarum*, Jameson. A species of "pearl oyster" that was formerly very common in the waters of Southern Australia, but is now restricted to warmer latitudes. Over 30 fragments were obtained of this shell from the present washing, but no complete valve. Further particulars are given in the article on the Brooklyn Park bore [Howchin, W., 1935, p. 83].

Occurrences:—Recent in the northern seas of Australia and subfossil in the Pleistocene [older raised sea-bed near Adelaide]. Adelaidean (Up. Plioc.): Common in the bores of the Adelaide basin. Kalimnan (Low. Plioc.): Murray River cliffs (S. Aust), Mallee bores (Vict.). Janjukian (Mioc.): Muddy Creek; Mallee bores (Vict.).

*Ostrea hyotidoidea* Tate. The sample of material now undergoing examination belongs to a very characteristic geological horizon which, on account of the prevalence of this shell, has received the name of the "oyster bed" in the Adelaidean Upper Pliocene. Single valves are extremely common in the present sample, which, in the aggregate, broken and whole, must represent 100 distinct individuals. Some of these are very turgid and massive—one lower valve (not complete) weighs 9 ounces. See further remarks under the "Brooklyn Park Bore" [Howchin, W., 1935, p. 82].

*Chlamys asperrimus* subsp. *antiaustralis* (Tate). Since Prof. Tate's time, on a question of priority, certain groups of the genus *"Pecten"* have been transferred to *Chlamys* Bolten, 1798; and some of these have been specifically examined and further revised by Gatliff and Singleton [1930]. In this revision the authors referred to consider that Tate's *P. antiaustralis* is a subspecies of the Recent *asperrimus* Lamk., and should bear the name as given above. The subspecies, as defined, "differs from *asperrimus* chiefly in the wider ribs and lamelliform character of the mature ornament."

Occurrences:—Adelaidean (Up. Plioc.): Moderately common, but mostly by fragments, some indicating large examples, and often determined solely on the ornamentation on the test fragments; at Cowandilla and other bores on the same horizon. Also Kalimnan (Low. Plioc.): At Upper levels, Aldinga (S. Aust.).

*Chlamys asperrimus* subsp. *dennanti* Chap. and Sing. In the *asperrimus* group there is not only a considerable range in individual variation, but some may be clearly distinguished, when mature, that are indistinguishable in their respective ephebic stages. Some varieties that occur in the Werrikooian, of the Glenelg River (Vict.), have been distinguished as a subspecies *(dennanti)* as above, which also probably occurs among the remains of the Adelaidean basin.

*Spondylus arenicola* Tate. Although no complete valve was obtained of this shell from the bore material, the characteristic spiniferous ornamentation that it carries, together with the typical dentition, seen in some of the fragments, are sufficient for its determination. The species is subject to considerable variation, both as to shape and ornamentation, and as these characteristics are also present in a species of the same genus living in the adjacent seas, some hesitation is felt in making a determination based on imperfect examples, but as the present remains occur with their known fossil associates elsewhere, the latter has weight.

Occurrences:—Adelaidean (Up. Plioc.): Recorded from all bores at this geological horizon. Kalimnan (Low. Plioc.): Very fine examples in the upper beds at Aldinga Bay; also at Hallett's Cove.

*Eucrassatella kingicoloides* (Pritchard). This is one of the largest and most abundant pelecypods in the Adelaidean material. All stages of growth are represented, in the present sample, up to a measurement of 75 mm. in length and 62 mm. in height, which exceeds that of Pritchard's type. The larger shells are mostly more or less in a broken condition, but the sum total of their occurrence, in the sample washed, must represent more than a hundred individuals. [See under "Brooklyn Park Bore." Howchin, 1935, p. 83.]

Occurrences:—Adelaidean (Up. Plioc.): Present in all the bores of the Adelaidean basin, at this geological horizon, often in considerable numbers. Kalimnan (Low. Plioc.): North-west Bend, R. Murray (S. Aust.); Jimmys Point. Kalimnan: Gippsland Lakes and "fairly abundant" in the Mallee bores (Vict.).

*Eucrassatella carnea* (Tate). A much smaller species than the preceding. Tate's type is 22 mm. in length and 19 mm. in height; largest bore specimen, length 16 mm., height 13 mm., surface concentrically ribbed.

Occurrences:—Recent: Shells on beach, dredged alive from Yankalilla Bay and off Rapid Head by Dr. Verco. Adelaidean (Up. Plioc.): Moderately common; first record of the species in a fossil condition.

*Venericardia trigonalis* (Tate). The left valve of an adult specimen from this material measures 9 mm. in length and 8 mm. in height; has 16 crenately-nodulose, rounded radiating ribs; a few shells in the ephebic stage of growth were also obtained.

Occurrences:—Adelaidean (Up. Plioc.): Cowandilla bore. Kalimnan (Low. Plioc.): Blanche Point, Aldinga Bay (S. Aust.); Mallee bores, Sorrento bore (Vict.). Janjukian (Mioc.): Mallee bores, Sorrento bore (Vict.).

*Venericardia* (?) *compacta* (Tate). About a dozen specimens obtained from this bore are placed, a little doubtfully, under this species. They range, in size, from 3 mm. by 3 mm. in the smallest, up to 7 mm. by 6·5 mm. in the largest. They show a general likeness to the species indicated but with some differences. The latter consist partly in the number of the ribs, as they possess 16 or 17 radial ribs as contrasted with the 24 ribs of *V. compacta*. They agree with the latter in that the ribs are furnished with a closely-set, crenately-granose ornamentation, that usually extends, like a bar, over the entire width of the respective ribs; while they also differ from the species named, again, in that the interspaces, which vary individually, are usually wider than the reported "linear interspaces" of the type.

Occurrences:—Adelaidean (Up. Plioc.): Abattoirs and Cowandilla bores (S. Aust.). Kalimnan (Low. Plioc.): Mallee bores, Sorrento bore (Vict.). Janjukian (Mioc.): Mallee bores, Muddy Creek, Sorrento bore.

*Lucina affinis* Tate. A small shell, the surface ornamented with concentric striae and the margin minutely crenulated.

Occurrences:—Adelaidean (Up. Plioc.): Dry Creek, Abattoirs, and Cowandilla bores. About a dozen examples in the latter, including many juveniles. Kalimnan (Low. Plioc.): River Murray, North-west Bend (S. Aust.); Sorrento bore (Vict.).

*Divaricella quadrisulcata* (d'Orbigny). A shell easily recognised by its distinctive ornamentation. Has a wide distribution as an existing species in the Australian, New Zealand and associated seas, known by its synonymic name *cumingi*. As a fossil it is limited to the Newer Tertiaries, and, in the present bore material, its separated valves occur in hundreds.

Occurrences:—Adelaidean (Up. Plioc.): In all the bores at this horizon in the local sinkings. Kalimnan (Low. Plioc.): Oyster bed, Murray cliffs, at North-west Bend (S. Aust.); also in the Wanganui (Tert.) Series (N.Z.).

*Loripes icterica* Reeve. Finely concentrically and radiately striated.

Occurrences:—A common Recent form in South Australian waters. Adelaidean (Up. Plioc.): Fairly common in present bore material, and in the Abattoirs bore (S. Aust.).

*Miltha (Milthoidea) grandis* (H. Woods). This large, compressed, and thick-shelled pelecypod forms one of the most striking features in the Adelaidean Upper Pliocene fauna. The genus has a Tertiary and Recent record, but in no case is it a common object, more particularly so with respect to the Australian

Region, so that its presence in the Adelaidean faulted basin is of much interest. Among the specimens collected from the Cowandilla bore was a nearly complete right valve that has a length of 82 mm. and a height of 81 mm., the thickness of the test at one-third distance from the umbo is 12 mm. [For further particulars see Singleton and Woods, 1934.]

Occurrences:—Adelaidean (Up. Plioc.): Tate notes the genus, without specific determination, as present in the Dry Creek bore; Miss N. H. Woods records it from the Abattoirs bore [1931]; portions of five valves were obtained, by the writer, from the Brooklyn Park bore [1935]; and six from the present bore. A new subspecies [*flindersiana* Sing. and Woods] has been described from a bore on Flinders Island, Bass Strait [1934, p. 207]. Kalimnan (Low. Plioc.): An allied imperfect shell from Beaumaris (Vict.).

*Meretrix sphericula* Tate and Basedow. This large, thin-shelled, inflated, and regularly convex pelecypod, has been badly preserved in a fossil condition. When unsupported by an internal compact cast it was easily reduced to fragments; and when filled tightly by the matrix was easily exfoliated on exposure, leaving only the internal cast, making a satisfactory diagnosis somewhat difficult, which may explain its late recognition, in the local fossil fauna. The determination made by the late Prof. R. Tate was posthumously published by Mr. H. Basedow [1902]. The holotype was obtained from Edithburgh (Y.P.), from which locality, as well as some others, the writer has obtained further examples.

Occurrences:—Adelaidean (Up. Plioc.): Glanville, Brooklyn Park and Cowandilla bores. Ten examples of incomplete valves were obtained from the last-named. Kalimnan (Low. Plioc.): Edithburgh, western side of Gulf St. Vincent; Aldinga (Up. Ser.); Hallett's Cove (S. Aust.).

*Antigona propinqua* (T. Woods). Formerly classed under *Venus* or *Chione*. The present material yielded two mature valves and a large number in various stages of growth.

Occurrences: Adelaidean (Up. Plioc.): Dry Creek, Abattoirs, Brooklyn Park, and Cowandilla bores. Kalimnan (Low. Plioc.): Muddy Creek (Up. Ser.), common; Mallee bores (Vict.). Janjukian (Mioc.): Table Cape (Tas.); Muddy Creek (Low. Ser.), rare.

*Antigona hormophora* (Tate). This and the following species agree, in a general way, with Tate's specimens, although the local examples are somewhat larger. Tate's dimensions of the above species are: length 65 mm., height 57 mm.; while the Cowandilla largest specimen measures, respectively, 72 mm. by 60 mm. The ornamentation is very strongly marked in both species and, in relation to the above, is defined by Tate as "numerous concentric lamellae . . . the interstitial spaces with numerous flattish radial ridges" [Tate, R., 1886-87, p. 155]. The numerous, very fine, and well-marked concentric ridges seen on the umbo, in the Cowandilla specimens, are not shown in Tate's figures, nor mentioned by him as a feature in his types. His figure of the present species appears to possess about 27 concentric ridges, as compared with about 55 such ridges in the Cowandilla examples; and, while the former are continued, uniformly, to the ventral margin, in Tate's figure, the marginal area, in the Cowandilla specimens (in a breadth of 10 mm.), is occupied by 10 closely-packed, small concentric ridges, separated only by lineal depressions. Two valves, right and left, that have identical features, fit exactly, and may have formed parts of the same individual shell.

Occurrences:—Adelaidean (Up. Plioc.): Two complete, right and left, valves, and fragments of others. Miocene: Table Cape (Tas.). Type locality.

*Antigona* (?) *dimorphophylla* (Tate). This is a slightly smaller species than the preceding, figured, but only very briefly described by Tate. The shell has, respectively, less height in relation to its length, is less inflated, and the umbo

is placed more posteriorly than the preceding. It possesses similar very fine and numerous concentric ridges on the umbo, as mentioned above with regard to the species *hormophora,* but are not shown in Tate's figure. Moreover, the relative number of concentric ridges, shown in Tate's figures to be more numerous in *dimorphophylla* than in *hormophora,* is reversely so in the Adelaidean examples. The present species is, presumably, represented by several single valves, none of which, unfortunately, is sufficiently complete for precise determination, but the specific distinctions have a strong probability.

Occurrences:—Adelaidean (Up. Plioc.): Abattoirs, Glanville, Brooklyn Park, and Cowandilla bores. Kalimnan (Low. Plioc.): Beaumaris, Royal Park (Vict.). Janjukian (Mioc.): Common in the calciferous sandstone of River Murray cliffs, Muddy Creek (Low. Ser.)

G. B. Pritchard has described two very similar species to the above under the names *Chione etheredgei* and *C. cognata,* the former from the Janjukian and the latter from the Kalimnan of Victoria. [Contribu. to the Pal. of the Older Tert. of Vict., Lamell, pt. iii, Proc. Roy. Soc. Vict., vol. xv (N.S.) 1903, pp. 87-103, pl. xii.]

*Tellina aequilatera* Tate. Ovately-oblong and subequilateral.

Occurrences:—Adelaidean (Up. Plioc.): Common in Brooklyn Park, Glanville, and Cowandilla bores (S. Aust.). Kalimnan (Low. Plioc.): Muddy Creek (Up. Ser.) (Vict.), and River Murray, Nor'-west Bend (S. Aust.).

*Tellina* (?) *albinelloides* Tate. Shell, elongated oval; length, 28 mm.; height, 15 mm.; exterior ornamented with fine, regular, concentric striae.

Occurrences:—Adelaidean (Up. Plioc.): Dry Creek and Cowandilla (one example) bores (S. Aust.). Kalimnan (Low. Plioc.): Common in upper beds of Muddy Creek (Vict.).

*Corbula (Notocorbula) ephamilla* Tate. The right valve is concentrically corrugated; left valve nearly smooth with irregularly striated lines of growth.

Occurrences:—Adelaidean (Up. Plioc.): Dry Creek, Croydon, Abattoirs, Brooklyn Park, Glanville, and Cowandilla (very common) bores. Kalimnan (Low. Plioc.): River Murray, Nor'-west Bend; Mallee bores, upper bed of Muddy Creek, Sorrento bore (Vict.). Janjukian (Mioc.): Lower bed of Muddy Creek, lower part of Sorrento bore (Vict.); Table Cape (Tas.).

*Corbula (Notocorbula) pixidata* Tate. Both valves ornamented with fine and close-set concentric ridges. [*C. compressa* Verco is a synonym of this species.]

Occurrences:—Adelaidean (Up. Plioc.): Cowandilla, rather scarce. Kalimnan (Low. Plioc.): Mallee bores, Sorrento bore (Vict.). Janjukian (Mioc.): Muddy Creek, Sorrento bore (Vict.); Table Cape (Tas.).

*Corbula (Notocorbula)* sp. undetermined. Shell strongly convex. Right valve, length 12 mm., height 10 mm.; umbo prominent and incurved; posterior margin obliquely truncated; surface smooth and, in well-preserved specimens, polished, with faint concentric (? colour bands); a few irregularly placed, depressed radial ridges with very fine and closely-packed radial lines, only seen by a magnifying lens; has a single strong vertical tooth. Left valve, few examples recognised as compared with the right, and a little indefinite, as no shell was found with both valves attached; surface marked by concentric laminae, somewhat irregular in outline, and, in some, a few depressed radial ridges, but not so characteristic as those seen in the right valves. There is some difficulty in distinguishing the left valve of this species from the left valve of *C. ephamilla.* Not uncommon in the Cowandilla bore.

*Saxicava australis* Lamk. From the bore material were obtained, one right valve, with a length of 24 mm. and height of 15 mm.; also a juvenile shell with a length of 10 mm.

Occurrences:—In existing seas this genus is almost cosmopolitan in distribution, from the Arctic to Cape of Good Hope, including the Australasian Region. Adelaidean (Up. Plioc.): Dry Creek, Abattoirs, and Cowandilla bores. Kalimnan (Low. Plioc.): Gippsland Lakes (Vict.). Janjukian (Mioc.): Aldinga (S. Aust.); Muddy Creek, Cape Otway, and Mornington (Vict.).

## Scaphopoda.

Dentaliidae. A group of tubular molluscs that show considerable individual variations which make specific distinctions often difficult. In discussing the species *Dentalium aratum* Chapman and Gabriel remark, "A critical examination of the Recent related forms of the above genus has resulted in the following conclusions: The Australian Dentaliidae form a large group, the characters of which show a great amount of variation. *D. aratum* is no exception, and the species most likely to be confused with that form are the living *D. robustum* Brazier, *D. intercalatum* Gould, and *D. francisense* Verco. *D. robustum* can be separated by the absence of longitudinal striae. A constant feature of the costation in *D. intercalatum* is in the ribs becoming distinctly rounded in later growth. In the case of *D. francisense* we agree with Verco who remarks, "I am inclined to think that even this species is but an extreme variant of the *D. intercalatum* Gould." [Chap. and Gab., 1914, p. 314.]

*Dentalium intercalatum* Gould. Has priority over other names. Verco's observations on this species are very suggestive. [Verco, 1904, p. 136.] He states, "The number of ribs very rarely remains the same throughout the entire length of the shell." This increase occurs in two ways: 1, By intercalation, when secondary, or more, riblets are developed in the interspaces; and 2, By rib-splitting, when a groove is formed, which gradually widens until the single rib becomes duplex. Either of these methods, or both, may occur in the same individual. Verco had under examination more than 300 dredged individuals, and states, "I have vainly endeavoured to discover more than one species among them. They are exceedingly variable, and were it not for intermediate forms quite a dozen species might be created" *(loc. cit.,* p. 135).

Among these variants in the Cowandilla bore the following may be mentioned:—

*Dentalium intercalatum aratum* Tate. A small graceful shell, distinctly curved. Tate says, "The ornament varies in the acuteness and strength of the ribs and, therefore, in the depth of the interspaces; in some specimens, by reduction in volume of the primary ribs and the increased size of the intermediate ones, the anterior part is subrotund and multicostated." [Tate, R., 1886 7, p. 192.] In the Cowandilla specimens the ribs at the posterior end are acute and prominent, which become reduced in size towards the apertural end with a corresponding widening of the intermediate spaces in which faint secondary riblets appear, and, in well-preserved specimens, fine transverse striations occur.

Occurrences:—Adelaidean (Up. Plioc.): Thirteen examples; the longest has a length of 25 mm.; diameter of aperture, 3 mm. Janjukian (Mioc.): Muloowurtie, Ardrossan, Murray Cliffs, Morgan (S. Aust.); Muddy Creek (lower bed) and Schnapper Point (Vict.).

*Dentalium intercalatum francisense* Verco. Shell moderately solid; number of ribs 11, more or less; ribs round, or broad and flattened; ribs frequently split at varying distances from the posterior extremity, producing duplex ribs, which may, again, subdivide. Dredged by Verco off St. Francis Island, Cape Borda, Gulf St. Vincent, and Geographe Bay, Western Australia. The only fossil record is from Cowandilla bore, several imperfect examples, the longest 25 mm.

*Dentalium intercalatum* var. Certain examples occur in this material that have a nearly smooth surface with about 15 very narrow, low, thread-like ribs with wide interspaces, maintained with great regularity. Sometimes a weak and scarcely recognisable riblet is present in the centre of the interspaces. The shell surface shows concentric lines of growth. Seven fragments of this kind were obtained, the longest measures 13 mm. with a transverse diameter of 2 mm.

*Dentalium* sp. (undetermined). Fragments only. Shell large and strong; longest piece 28 mm., breadth 7 mm.; ornamented with broad ridges separated by narrow interspaces; or numerous ridges, of various sizes, irregularly deposed, massed in places and fading in others; numerous annular constrictions and very fine concentric striae. I cannot refer these specimens to any known species, either Recent or fossil. Four examples.

GASTEROPODA.

*Emarginula dennanti* Chap. and Gab. A unique but imperfect specimen was obtained from this horizon, consisting of the apical portion of the shell—the marginal testaceous base, including the "slit," is absent through fracture. The evidences available for determination show that the shell belongs to the Fissurellidae, the shell is oval and conical in outline, the apex recurved and situated postmedially, the surface cancellated. The fragment, although only 6 mm. in length, agrees very closely with the above species [Chapman, F., and Gabriel, C. J., 1923, p. 27], having about 24 primary, radiating ribs with secondary riblets, and these are crossed by concentric ridges with tegulated prominences at the intersections. The latter, especially on the primary ribs, by abrasion, show worn surfaces, and these, when viewed through a compound microscope, expose a pseudo-septate or cellular structure.

Occurrences:—This fragment from the Cowandilla bore is the only record of the fossil in the Adelaidean beds. Chapman and Gabriel give the following localities: Balcombian (Oligocene) type from Grice's Creek (J. F. Bailey coll.). Also from Altona Bay coal shaft, Balcombe Bay and Muddy Creek (Cudmore coll.), Muddy Creek (Dennant coll.). Janjukian (Mioc.): Gellibrand River (Cudmore and Parr coll.). An internal cast of a related, if not identical, shell occurs in the Murray cliffs at Morgan (F. A. Cudmore coll.).

*Phasianella australis* Gmelin. A common living species in the local seas. Although no shells of this gasteropod were obtained from the present bore material, its presence was clearly indicated by the occurrence of several characteristic opercula, of medium size. Its first record as a fossil.

*Calliostoma* sp. No. 1 (undetermined). Specimen incomplete, consisting only of the base and penultimate whorl of the spire. Shell nacreous internally. Diameter of base, 22·5 mm. Base flat and keeled. The portion of spire preserved is ornamented with granulous spiral ridges, separated by smaller and, mostly, non-granulous spirals. The base is ornamented with ten concentrically encircling ribs of uniform size, faintly granulous. The four outer circles carry single, smaller, interstitial riblets in the depressions between the stronger ribs.

This fragment shows some likeness to *C. rubiginosum (Valenciennes = Trochus nobilis* Philippi), a Recent South Australian species, but can be easily distinguished.

*Calliostoma* sp. No. 2 (undetermined). Five examples of a small and very ornamental shell were obtained from this material. The largest of these, which has lost about half the spire by fracture, had a diameter of 8 mm.; the next in size, which is complete, has a diameter of 5 mm. and a height of 6 mm.; the smallest measures 2·5 mm. by 2·5 mm. The second mentioned is selected for description. The shell is acutely conical, the protoconch makes three turns and

is smooth and colourless. There are six whorls. Towards the apex the first three or four whorls have close-set spiral ribs and are crossed by equally close-set radial ribs, both sets are closely charged with granules. A thicker and somewhat prominent spiral rib originates not far below the summit, increasing in size as it descends, ultimately forms a prominent and somewhat overspread peripheral keel This dominant rib carries somewhat larger granules than the rest, and the latter take the form of vertical bars, while the rib, as a whole, shows numerous fine, longitudinal striations. Four secondary ribs occupy the spaces between the chief spiral, which are also granulous. The base is ornamented with eight concentric and encircling rounded ribs.

*Clanculus* sp. (aff. *dunkeri* Koch.). A single specimen only. Diameter, 6·5 mm.; height, 6 mm.; slightly depressed, consisting of five whorls. Protoconch smooth, making one and a half turns. Aperture ovately-subangular, nacreous, columella with bidentate terminal; outer lip costated internally; periphery rounded, marked by a spiral of larger beads; penultimate whorl carries two granulous spirals, increasing in size, followed by an infra-sutural row of granules that are still larger. Above the sutural depression the same order of granulous spirals follow in decreasing strength with an apical band of exceedingly fine granulous spirals below the protoconch. The interstitial depressions, separating the granulous lyrae, are covered by fine oblique threads. The last whorl is somewhat gibbous and ornamented with nine concentric spirals feebly marked by granules, and the depressions by fine oblique threads. The shell has a general likeness to *C. dunkeri*, but is evidently distinct.

*Callomphala (Teinostoma) depressula* (Chap. and Gab.). Six examples, well preserved and showing good polish. Greatest diameter, 2·5 mm. Agree in all particulars with the figured type.

Occurrences: —In 1878 Tate described a related species from Gulf St. Vincent under the name *Ethalia* (?) *cancellata* [1879, p. 139], afterwards altered to *Teinostoma cancellata*. Differs from the present species in being considerably larger, more lenticular in shape, and carries fine cancellated striae. Adelaidean (Up. Plioc): Only known from Cowandilla bore. Kalimnan (Low. Plioc.): Occurred in three samples in Mallee bore, No. 10, "all of which contain a Kalimnan fauna."

*Cyclostrema homalon* Verco. Twelve examples. Longest diameter of largest specimen, 3 mm. Reported by Chapman from a Kalimnan horizon in the Mallee bore, No. 10. Dredged by Verco off Capes Borda and Jaffa.

*Neodiastoma provisi* (Tate). This is one of the largest and most characteristic gasteropods in the Adelaidean Upper Pliocene. [Tate, R., 1893, p. 177.] Sixteen specimens were obtained from the present bore material, the largest has a length of 45 mm.

Occurrences:—Adelaidean (Up. Plioc.): Found in all the examined material from bores at this horizon, generally quite common. The only occurrences recorded outside the above-mentioned area and horizon are Tate, Hallett's Cove, and Howchin, in the small outlier at Marino, near Brighton (S. Aust.), both of Lower Pliocene age. A related form has been recorded by Chapman from Vivonne Bay, Kangaroo Island.

*Zeacrypta (Crepidula)* aff. *dubitabilis* (Tate). The "Slipper Limpet." The shell has an oval outline, in juvenile examples the dorsal surface is somewhat depressed, but, in maturity, is strongly convex marked with growth lines; apex submarginal. Seven specimens were obtained from Cowandilla, the largest has a length of 28 mm., and breadth 20 mm.; the smallest 5 mm. by 4 mm. Differs in minor particulars, but can be, provisionally, placed with the above species.

Occurrences:—Adelaidean (Up. Plioc.): Seven examples. One, apparently the same species, measuring 30 mm. by 22 mm., was obtained from the Brooklyn

bore. Kalimnan (Low. Plioc.): Gippsland Lakes (Vict.). Janjukian (Mioc.): River Murray cliffs, (S.Aust.) and Mornington (Vict.).

*Calyptraea (Sigapatella) undulata* Tate. Shell thin and orbicular in outline; spire elevated with a circinately-coiled apex. Ten examples, immature and small, the largest measuring 6 mm. in diameter, but as the sharp and delicate periphery, in each case, has been damaged, the true diameter is not shown.

Occurrences:—Adelaidean (Up. Plioc.): Only known in this bore. Janjukian (Mioc.): River Murray cliffs (S. Aust.); Muddy Creek (Vict.).

*Polinices (Natica) subvarians* (Tate). Three examples, all more or less imperfect.

Occurrences:—Adelaidean (Up. Plioc.): Brooklyn Park, Glanville, and present bore. Kalimnan (Low. Plioc.): Hallett's Cove, Aldinga (Up. Ser.) (S. Aust.); Gippsland locality (Vict.).

Turritellidae. This family of gasteropods is abundantly represented in the Adelaidean Upper Pliocene, in small examples, the examination of which has been deferred, especially as the group, including closely related genera, is under critical revision at the present time. [Since the above was written Mr. Cotton and Miss N. H. Woods have published their paper on this subject. See References at end.]

*Vermicularia (Thylacodes) sipho* (Lam.). Was described by Lamarck under *Serpula*. Has a vermiform or tubular test in a twisted irregular growth, more or less spiral. The surface has concentric growth lines crossed by numerous, fine, longitudinal costae. It is a common Recent form, often found cast up on the beach. In the present bore the remains are much weathered and chalky and much broken up. The longest fragment measures 35 mm. in length, and the largest apertural diameter measures 12 mm. A large fragment was caught during life between two oyster shells which, by their united growth, enclosed it. Another fragment is enclosed within a solid mass of argillaceous limestone. This appears to be its first record in a fossil condition.

*Siliquaria australis* Q. and G. Tubular with a spiral commencement, subsequently irregularly coiled. Can be distinguished from *Vermicularia* by possessing a longitudinal slit or fissure, which is sometimes bridged and thereby reduced to perforations. Common in shallow water and on beaches in South Australia.

Other Occurrences:—Adelaidean (Up. Plioc.): Cowandilla, common. Janjukian (Mioc.): Collected by the author at Hackham, McLaren Vale and River Murray cliffs (S. Aust.).

*Pelicaria howchini* Cotton [Cotton, B. C., 1934]. In relation to this species Mr. Cotton has favoured me with the following note: "This is a typical fossil of the Upper Pliocene and is distinguished from *P. coronata* Tate by the non-canaliculate sutures. The latter species is typical of the Lower Pliocene and occurs in the deposit at Vivonne Bay, Kangaroo Island, together with *Neritina* and tropical species of *Nerita*. Chapman [Association for Advancement of Science, 1935, p. 125] records the Vivonne Bay deposit as Upper Pliocene, but the remains are typically those of the Lower Pliocene." Mr. Cotton has also called my attention to the use of the term *Tylospira* for this genus *(Pelicaria)*, by some writers, as being unwarranted. Thiele, in his Handbuch der Systematischen Weichterkunde, pt. i, p. 251, 1929, gives *Tylospira* Harris, 1897, as a synonym of *Pelicaria* Gray, 1857; so that, on a question of priority, the latter must be retained.

Occurrences:—Adelaidean (Up. Plioc.): All bores, at this horizon, in the Adelaide basin. In the present bore, abundant, but badly preserved.

Cerithoid shell. Two fragments of the same large species obtained from the Glanville bore [Howchin, W., 1935, p. 90] and described as a new species in an Appendix to the present paper, were obtained from the present bore. Both

specimens are portions from near the aboral end; one measures 27 mm. in length, and the other 18 mm.; the ornamentation of the surface, in each case, is well preserved.

*Erato minor* Tate. One example, in good condition, white and shiny. Length, 5 mm.; width, 3 mm.

Other Occurrences:—Janjukian (Mioc.): Muddy Creek (Vict.); River Murray cliffs (S. Aust.).

*Nassaria (Nassa) tatei* (T. Woods). Thirty-two examples were obtained from this bore material; they are small but typical.

Other Occurrences—Janjukian (Mioc.): Muddy Creek (Vict.); River Murray cliffs (S. Aust.).

*Marginella atypha* (Tate). Agrees with Tate's *Mitra atypha*. A single small specimen. Length, 4 mm.; breadth, 2·5 mm.

Other Occurrences:—Kalimnan (Low. Plioc.): Muddy Creek (Up. Ser.), Vict.

*Ancilla (Ancillaria) semilaevis* T. Woods. A single example. Length, 8 mm.; breadth, 3 mm.

Other Occurrences:—Janjukian (Mioc.): River Murray cliffs (S. Aust.); Muddy Creek (Low. Ser.), Vict.

*Oliva adelaidae* Tate. One example. Length, 6 mm; breadth, 3 mm.

Other Occurrences:—Miocene: Kent Town bore.

*Pupa* Bolten [non Lamk.] sp. (indeterminate). A single imperfect specimen, including the body whorl but not the spire. Judging from the fragment available it has some resemblance to the Recent shell *Pupa (Buccinula) intermedia* Angas, but it is smaller, the body whorl less globose, and is differently coloured. Height (of fragment), 5 mm.; diameter, 3 mm.; length of aperture, 4·2 mm.; is of a uniform brownish colour, and surrounded by fine spiral threads. The genus is represented by two species in South Australian waters, mostly dredged, and not common.

*Cylichnella callosa* Tate and Cossm. An opisthobranch gasteropod. Twelve specimens, all more or less juvenile; the largest has a length of 8 mm. and a breadth of 2·5 mm.

Occurrences:—Rare in distribution. Miocene of Aldinga (S. Aust.) and Cape Otway (Vict.) are the only records.

*Tornatina aptycha* Cossm. This is another opisthobranch gasteropod.

Occurrences:—Adelaidean (Up. Plioc.): Three examples, Cowandilla bore. Janjukian (Mioc.): Muddy Creek (Low. Ser.), Vict.; Table Cape (Tas.). Reported by Chapman from the Mallee bores, but the horizon is, apparently, not indicated.

### Pteropoda.

(?) Pteropod fragment. A V-shaped vessel with oval aperture, dull white colour, height 5 mm., greatest breadth 4 mm., showing eight parallel bands of growth. The upper edge is a line of fracture. Zoological position doubtful—seems most likely to be portion of a pteropod.

### Decapoda.

Two maxillipedes of a small crab.

### Pisces.

Fish remains are, in a general way, rather scarce and consist mainly of such as consist of hard parts and a fair size.

1. *Diodon* sp. Palatal plate, being part of the dental appliance of the Porcupine or Globe Fish that lives in the local seas and is sometimes cast up on

the beach. The plate measures 23 mm. by 20 mm. Portions of the armature of the jaw of the same kind of fish were obtained from the Glanville bore.

2. Otoliths. A great number of small otoliths, ranging in size from 1 mm. to 7 mm., in the longer diameter, were obtained from this bore, probably representing several species of fish.

3. A promiscuous variety of small fish bones were selected that are indeterminable.

No remains of Sclachians were obtained.

*End of the Chief Fossiliferous Zone—470-507 Feet.*

**Depth, 510 ft.**—A fine-grained incoherent silt, like the last sample. The only large fossil was a complete shell of *Polinices subvarians* (Tate), which was probably derived from the overlying bed. In other respects the larger material was limited to shell breccia. The foraminifera, moderately common. Other observations made were, one example of *Lucina affinis* Tate, *Tellina aequilatera* Tate, two small gasteropods, and the mandible of a small decapod crustacean.

**Depth, 515 ft.**—A loose, greyish silt, limited to objects of rarely more than a few millimetres in diameter; the larger composed of angular shell fragments, the organic remains, otherwise, being very scarce. There came under observation, a few very minute mollusca, mostly imperfect; polyzoa very rare, and a considerable number of fragments of a rough cellular kind that are probably the triturated remains of the cellular structure in the pelecypod *Mintha grandis*, as previously suggested. Foraminifera scarce and small.

**Depth, 520 ft.**—Argillaceous silt with more clay than in the preceding, which gives more cohesion to the bed but goes down easily in water. Shelly fragments rather larger than in the last sample but are rarely sufficiently complete for determination. Most of the organic remains are of almost microscopic size.

FORAMINIFERA.

*Triloculina trigonula* Lamk.
*Quinqueloculina linnaeana* d'Orb. *Q. ferussacii* d'Orb.
*Spiroloculina* aff. *arenaria* Br.
*Guttulina yabei* Cush and Oz. *G. regina* (B. P. and J.).
*Sigmoidella elegantissima* (P. and J.). *S. kagaensis* Cush and Oz.
*Discorbis turbo* (d'Orb.).
*Elphidium striatopunctatum* (F. and M.). *E. macellum* (F. and M.).
*Rotalia beccarii* Linné. *R. howchini* Chap., Parr and Coll.

PELECYPODA.

*Nucula (Pronucula) micans* Angas. Several examples with a length of 2·5 mm. Recent, Gulf St. Vincent.

*Austrosarepta (Lissarca) rubricata* (Tate). Several examples, varying in length from 1·0 mm. to 2·0 mm., have several small nicks on the ventral edge. Recent, in Gulf St. Vincent.

*Lucina araea* Tate.

*Tellina aequilatera* Tate. *T. albinelloides* Tate. These are the only forms in the fossil remains of the sample to reach a moderate size.

GASTEROPODA.

*Calyptraea (Sigapatella) undulata* Tate. One imperfect specimen.
*Nassaria tatei* (T. Woods).
*Tornatina aptycha* Coss. A small [3·5 mm.] but perfect specimen.

*Pupa* Bolten [non Lamk.] (?) *intermedia* (Angas). A broken specimen.

*Cyclostrema homalon* Verco. Recent, in South Australian waters.

SUNDRIES.

POLYZOA.—Moderately common and varied. In a broken-up condition; may have contributed to the irregular cellular structures that are common in the residue from washing.

OSTRACODA.—Occur only as single separated valves.

ECHINODERMATA.—Plates and spines of echinids.

PISCES.—Otoliths of teleostean fishes.

**Depth, 525 ft.**—Dark-coloured friable silt, carries very few visible organic fragments. Under examination the recognisable fossils were almost limited to such as were of nearly microscopic size.

FORAMINIFERA.

These are well represented, some species exceedingly common.

*Triloculina trigonula* Lamk.

*Quinqueloculina linnaeana* d'Orb. *Q. oblonga* Terq. *Q. ferussacii* d'Orb.

*Spiroloculina* aff. *arenaria* Br. More common than usual.

*Cribrobulimina mixta* (syn. *polystoma)* (P. and J.).

*Sigmoidella elegantissima* (P. and J.). *S. kagaensis* Cush. and Oz.

*Guttulina spicaeformis* (Roemer) var. *australis* (d'Orb.), fusiform in outline with elongated chambers and longitudinally costated, the costae coarser than those in *G. regina*. *G. problema* (d'Orb.). *G. (Sigmoidina) pacifica* Cush and Oz. The last-named bottle-necked with longitudinal chambers.

*Discorbis turbo* (d'Orb.).

*Epistomella polystomelloides* (P. and J.). One example.

*Rotalia beccarii* Linné. *R. howchini* Chap., Parr and Coll.

*Elphidium macellum* (F and M.).

PELECYPODA.

The coarser residue, after passing through the sieves, consisted mostly of triturated bivalve shells, among which the thicker parts of the shell, *Miltha (Milthoidea) grandis* H. Woods, formed some of the larger pieces. The smaller species had been better preserved than the larger ones and constitute the greater number of the recorded forms.

*Ostrea* sp. A few neanic examples.

*Antigona propinqua* (T. Woods). A much weathered valve of this species was the only fossil of moderate size obtained from the washing; but there were five other small examples of the species in good condition.

*Tellina aequilatera* Tate; *T.* (?) *albinelloides* Tate; *T.* (?) *masoni* Tate.

*Loripes icterica* Reeve. *L. simulans* Tate.

*Lucina affinis* Tate.

*Austrosarepta (Lissarca) rubricata* Tate.

GASTEROPODA.

*Vermicularia (Thylacodes) sipho* (Lamk.).

*Polinices subvarians* (Tate). A few juvenile specimens.

*Nassaria (Nassa) tatei* (T. Woods).

*Cyclostrema homelon* Verco.

*Callomphala (Teinostoma) depressula* (Chap. and Gab). One example, measures 2·2 mm.

*Cylichnella callosa* Tate and Coss.

SUNDRIES.

POLYZOA.—In considerable numbers and variety, but much weathered.
ECHINODERMATA.—Spatangoid spines, cidaridid tuberculous plates.
OSTRACODA.—Some species quite common, mostly single valves.
ANNELIDA.—*Cadulus acuminatus* Tate, one good specimen.
PISCES.—Undeterminable fragments, otoliths, small coprolites.

**Depth, 530 ft.**—A dark-coloured silt precisely similar to the preceding sample. The larger fragments consisted mainly of broken shells, among which were recognised *Ostrea*, part of a valve of *Spondylus arenicola* Tate, the dorsal portion of a valve of *Meretrix sphericula* Tate, a single valve of *Antigona propinqua* (T. Woods), and a small *Neodiastoma provisi* (Tate). The balance was made up of small objects seldom exceeding a few millimetres in extent, and the fauna, generally, corresponded with that at the 525-feet level, although in some instances in somewhat greater numbers. Among the rarities was a portion of a very small shell belonging to the Patellidae with the apex and basal portions missing, the whole measuring only 2·0 mm. in length. It is probably akin to another example of this family recorded from the 485-507-feet level [*ante*, p. 17], under the genus *Emarginula*.(1) The foraminifera differed little from former lists; those worthy of mention are, the arenaceous *Spiroloculina*, with a speckled black and white test, *Quinqueloculina seminulum*, *Adelosina bicornis*, and *Marginulina costata*.

**Depth, 535 ft.**—A dark-coloured incoherent silt which in water has the appearance of black mud. Before treatment gives no visible signs of organic remains. Coarse residue from washings, apart from two pieces of oyster shells, consisted mainly of shell-detritus in pieces a few millimetres square. The recognisable fossils are either of microscopic size or examples mostly below the normal size.

FORAMINIFERA.

*Pyrgo elongata* d'Orb. One imperfect specimen.
*Triloculina trigonula* Lamk. *T. gracilis* d'Orb.
*Quinqueloculina linnaeana* d'Orb.
*Spiroloculina* aff. *arenaria* Br. Speckled arenaceous test.
*Clavulina* (?) *parisiensis* d'Orb. Uniserial chambers only.
*Marginulina costata* (Batsch).
*Sigmoidella elegantissima* (P. and J.) *S. kagaensis* Cush. and Oz.

*Guttulina spicaeformis* (Roemer) var. *australis* (d'Orb.). Resembles *G. regina* (B. P. and J.), but the chambers are elongated and carry stronger costae. *G. problema* (d'Orb.).

*Cibicides lobatulus* (W. and J.).

*Epistomella polystomelloides* (P. and J.).

*Rotalia beccarii* (Linné). Abundant with large examples. *R. howchini* Chap., Parr and Coll. Abundant with large examples.

*Elphidium* aff. *craticulatum* (F. and M.) (variety). This is a variety of the species, with which it closely agrees except in being compressed, where it resembles *E. macellum* (F. and M.). The specimens are large and have a glassy, almost clear shell substance throughout which, in a measure, obscures the septation. They have a graceful appearance and are common. There are a few smaller forms that approach *E. crispum* and *E. macellum* as species.

*Marginopora vertebralis* (Q. and G.). Formerly classed under *Orbitolites complanata* Lamk., which latter is now restricted to an Eocene species. The late

(1) A complete shell of this species (length, 8 mm.; width, 5·8 mm.) was obtained from the Glanville bore, at a depth of 375-400 feet, but was overlooked at the time.

Tertiary and Recent forms are now distinguished as above. One example in present material, not quite perfect.

## Pelecypoda.

*Vermicularia (Thylacodes) sipho* Lamk. The spiral base of one specimen shows the surface of attachment; also fragments of the tubes.

*Pronucula micans* (Angas). A very minute shell, occurs in the beach sand of Gulf St. Vincent.

*Leda* (subgen. *Scaeoleda) verconis* Tate. A minute shell, measures 1·5 mm.; dredged in Gulf St. Vincent, etc. Was compared with Recent examples.

*Austrosarepta (Lissarca) rubricata* (Tate). Was placed by Tate under *Limopsis.* Very minute, specimens measure—antero-posterior—1·0 mm. to 2·0 mm. Dredged from Backstairs Passage, etc.

*Tellina aequilatera* Tate.

*Lucina araea* Tate; *L. affinis* Tate.

*Corbula (Notocorbula) ephamilla* Tate.

*Loripes icterica* Reeve.

*Venericardia (Cardita)* aff. *trigonalis* (Tate). Length 6·0 mm., height 6·0 mm., with 12 strong radial ribs; much weathered.

## Gasteropoda.

*Nassaria (Nassa) tatei* (T. Woods).

*Polinices subvarians* (Tate).

*Cyclostrema homalon* Verco.

*Callomphala (Teinostoma) depressula* (Chap. and Gab.).

*Zeacrypta (Crepidula)* aff. *dubitabilis* Tate. A small neanic specimen, but complete.

*Pupa* Bolten [non Lamak.] aff. *intermedia* (Angas). A small and imperfect specimen, probably the same species as the one recorded from the 485-507-ft. level.

*Rhizorus rostratus* Adams [Opis.]. Three examples. A common Recent Australian form.

*Cylichna pygmaea* Adams [Opis)] Recent occurrences near Port Lincoln. Nine examples.

## Sundries.

Polyzoa.—In considerable numbers and variety. One interesting species, not previously met with, is in the form of a minute inverted cone, pointed at the base, widening rather rapidly in its upward growth with a circular and approximately level surface. The zooecia form tubes, that lie side by side in a radial position, occupying about one-third of the marginal surface, while the oral apertures form the periphery. The central portions of the zoarium consist of massed vesicular tissue. The single specimen obtained from the present sample measures 1·5 mm. in height and 2·0 mm. in greatest breadth. Later, at greater depths, specimens were obtained up to 2·0 mm. by 3·0 mm. in height and breadth.

Annelida.—A broken specimen of *Ditrupa cornea* var. *wormbetiensis* McCoy.

Ostracoda.—Moderately common.

[Also the usual microzoa pertaining to echinoderms and fishes.]

**Depth, 540 ft.**—Dark-greyish, incoherent silt showing only slight indications of organic remains. Residue from washings, chiefly pelecypod fragments within a centimetre grade as to size.

### Foraminifera.

*Triloculina trigonula* Lamk.

*Spiroloculina* aff. *arenaria* Br. *S. grata* Terq. Test ornamented with strong longitudinal ribs.

*Clavulina parisienses* d'Orb. Originally named from specimens in the Eocene of Paris. In present seas at all depths down to 3,000 fathoms.

*Sigmoidella elegantissima* P. and J. *S. kagaensis* Cush. and Oz.

*Sigmoilina tenuis* Cj. Two specimens.

*Guttulina problema* d'Orb.

*Pyrulina* sp.

*Cribrobulimina mixta* (syn. *polystoma)* P. and J. sp.

*Cibicides lobatulus* (W. and J.).

*Discorbis vesicularis* Lamk., *D. turbo* (d'Orb.).

*Rotalia beccarii* Linné. Very common. *R. howchini* Chap., Parr and Coll. Very common.

*Elphidium* aff. *craticulatum* F. and M.; *E. macellum* (F. and M.); *E. crispum* (Linné.).

### Pelecypoda.

*Pronucula micans* Angas. One good example.

*Glycymeris convexa* Tate. One small example.

*Corbula (Notocorbula) ephamilla* Tate.

*Tellina aequilatera* Tate. The Tellinidae form the greatest part of the fossil remains.

*Austrosarepto Lissarca rubricata* (Tate). Two specimens.

*Loripes icterica* Reeve.

*Lucina affinis* Tate.

*Divaricella quadrisulcata* (Tate). One neanic specimen.

*Antigona propinqua* (T. Woods). Two examples.

### Scaphopoda.

*Dentalium intercalatum aratum* Tate. One imperfect example.

### Gasteropoda.

These are rare, small, and mostly imperfect.

*Cyclostrema homalon* Verco. One example.

*Rhizorus rostratus* Adams [Opis.].

*Cylichna pygmaea* Adams [Opis.].

### Sundries.

Similar to the preceding, including another example of the rare cone-shaped polyzoan.

**Depth, 543 ft.**—Only three feet separate this sample from the preceding one, but differs considerably from the latter in the nature of the sediment. In the dry condition it is a hard black mud with no signs of anything else. After washing, the larger fragments, that average about a quarter of an inch in diameter, consist of pellets of the bedding made adherent by the presence of calcareous cellular structures. Mixed with these are fragments of rather thick bivalve shells that give no direct evidence as to their origin. There is an almost entire absence of molluscan remains that can be recognised. The minute pelecypod valves that have been the chief evidences of mollusca in the upper levels are here entirely absent. There are a few polyzoa, greatly weathered, that include three additional

examples of the rare inverted cone species. The foraminifera are fewer than usual and, generally, are not so well preserved. Those worthy of mention are *Elphidium* aff. *craticulatum* (F. and M.), which are common and attain a size equal to 2·2 mm.; a very fine example of *Adelosina bicornis* (W. and J.); and two examples of *Nodosaria comata* Batsch, thick-set stumpy tests, showing five chambers with an extreme length of 2 mm. The foraminifera, as well as the other microzoa, are commonly encrusted by gritty particles which obscure the surface. Glauconitic grains are present, as in other levels, as well as a considerable number of jet-black particles, rounded, irregular, and sometimes angular in outline, which, while present at all fossiliferous depths, seem particularly numerous in the present sample; their origin is obscure.

**Depth, 545-548 ft.**—There is less clay, in the descending levels, from the last sample, the material being a light-grey free silt; three-fourths sand. Organic remains scarce and limited to objects of small size. The foraminifera are still represented most conspicuously by the large species *Elphidium* aff. *craticulatum*, which have the same defacing incrustations as mentioned above. The Polyzoa are moderately common in small weathered pieces, with larger lumps up to three-quarters of an inch of irregular cellular structure, which is sometimes set in a dark-coloured calcareous base which may, in part, be the product of broken-down polyzoal tissues. Two more examples of the polyzoan, having the shape of an inverted cone, were obtained from this horizon. A feature of these washings was the presence of a large number of broken annelid tubes. These were free, straight, or slightly curved, some contracted at the primordial end. They occur in fragments, measuring about one millimetre in breadth and five millimetres in length, probably belonging to the *Serpula socialis* group; also a few *Ditrupa cornea* var. *wormbetiensis*. The only pelecypod shells recognised were two fragments of *Divaricella quadrisulcata*, a neanic valve of *Loripes icterica*, and a single valve of *Austrosarepta (Lissarca) rubricata* that measured only 0·8 mm. in diameter. No remains of gasteropods were seen.

**Depth, 550 ft.**—An excessively fine and free quartz sand that mostly passes through the miller's finest silk sieves. Fossils rare and almost limited to microzoa. Foraminifera are limited in species and rather scarce, but include some very fine examples of *Elphidium* aff. *craticulatum* as well as other species, especially characteristic of the Upper Pliocene beds, as *Sigmoidella elegantissima*, *Epistomella polystomelloides*, *Discorbis turbo*, *Rotalia beccarii* and *R. howchini*. The Annelida, as in the previous sample, are represented by numerous short-length smooth calcareous tubes, straight or slightly curved, and a few *Ditrupa cornea* var. *wormbetiensis*. The Polyzoa are common in small pieces and disfigured by sand grains. The lumps of a dark-coloured limestone, up to 15 mm. in diameter, enclosing undefined cellular tissue, mentioned under the last sample, are present again in this sample, and have been probably derived from some other geological horizon. A weathered fragment of a *Tellina* sp. valve and two small imperfect gasteropods were all the mollusca noticed; two-toothed mandibles of small decapod crustaceans; and undefinable fish remains.

### 3. (?) Lower Pliocene.

*The bore was continued, further to a depth of 670 feet, but as the samples below the 550-feet level had gone astray, further examination was arrested. I am, however, indebted to the Assistant Government Geologist, Mr. R. W. Segnit, who most courteously supplied me with the personal notes he had made, at the time, in relation to that part of the boring covered by the missing samples. I very gladly incorporate these notes, which in a measure, fill the blank, and are as follows:*

**Depth, 550-599 ft.** (49 ft.).—Grey fossiliferous sands.
**Depth, 599-620 ft.** (21 ft.).—Light buff and fine fossiliferous (drift) sands. This buff sand came up the casing during drilling.
**Depth, 620-670 ft.** (50 ft.).—Bright yellow very fine sand.

## III—REMARKS ON THE GEOLOGICAL SECTION.

### 1. General.

*(a)* The first 400 feet consist of fluviatile deposits, varying in grade from fine to coarse, which represent the usual superficial sediments of the Adelaide Plains and can be classed with the newer River Systems of South Australia, and, locally, belong to the origin and development of the River Torrens.

*(b)* The second stratigraphical section consists of a fossiliferous series of greyish and dark-coloured silts, heavily charged with mud in a thickness of about 200 feet, from the 400-feet level to about the 600-feet level.

*(c)* The third and lowest section of the sediments reached consist of a light, buff-coloured, drift sand with marine fossils that was proved (in a thickness of about 50 feet) to the bottom of the bore at 670 feet.

### 2. Pleistocene.

The 400 feet of alluvial deposits show a disconformity both immediately above and below them. In the Glanville and Port Adelaide district these beds are overlain by two marine horizons, a Lower and an Upper Raised Sea Bed (now partly below sea level), the lower member of which may be regarded as of late Pleistocene age, and the underlying thick alluvial beds as belonging to a stage somewhat earlier. Tate, following a European terminology, designated these alluvial beds as "Mammaliferous Drift," as they carry the remains of extinct mammals.

### 3. Adelaidean (Upper Pliocene).

At about the 400-feet level a marked disconformity occurs, where the coarse fluviatile sediments give place to beds of a different lithological nature and that carry marine fossils. The conditions under which these fossiliferous beds were laid down are to some extent uncertain. It is only in a zone of about 37 feet that normal marine conditions appear to have existed, for whilst in this narrow belt marine life is abundant and includes shells of exceptional size, the rest of the beds, both above and below this rich fossiliferous zone, are almost destitute of fossils beyond those of almost microscopic size, whilst the debris of larger shells constitute the greater part of the organic remains. Moreover, as a six-inch core was cut, and often delivered intact, the shelly debris was not the result of the drilling tool, but arose from natural causes incidental to the deposition of the beds. The explanation seems to be that the sediments in this part of the section were essentially fluviatile in their origin, and that the organic remains found in them were either wholly, or in the main, derived from extraneous sources. Two sources may be suggested—One of these, the gradual sinking of the Adelaide trough, concomitantly with the rising of the land in the background, would, from time to time, leave behind mural fault scarps consisting of older fossiliferous formations, the waste of which would naturally come within the range of adjacent river currents and become mixed with the alluvial wash. Or, again, as the situation was near the outlet of a river, as well as in close proximity to the coastline (the sea certainly made a transgression over the area at one stage of the sedimentation), the prevailing winds would operate on the dry beach deposits and would carry light material inland, which might easily be dusted over the lower reaches of the river. The limitations of this agency may explain why the organic remains

through most of the deposits are so small. The foraminifera would especially be subject to such a means of transport. Evidences pointing in the same direction as suggested above were given in my previous paper, Part I, 1935.

### 4. (?) Lower Pliocene.

At about the 600-feet level another geological disconformity occurs, particulars of which the author, as stated above, is indebted to the courtesy of the Assistant Government Geologist (Mr. Ralph Segnit). There is the strongest contrasts in the nature of the sediments at this level as compared with those that overlie them, although they are both fossiliferous. In consequence of the samples from this section having gone astray no fossils are available for comparison, but there is the highest probability that these free, buff-coloured sands represent a distinct geological system from the overlying silts and, consequently, of greater age.

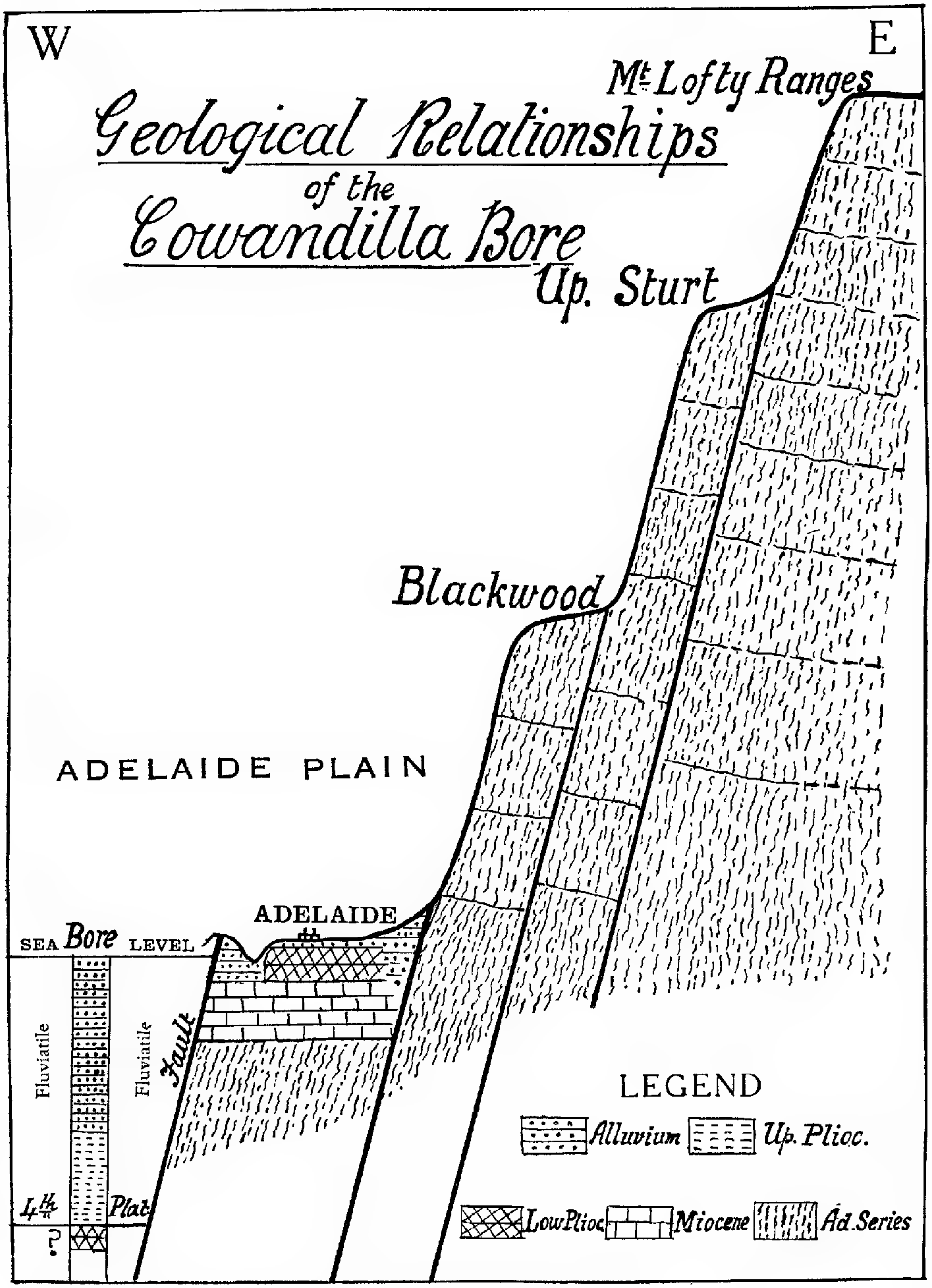
The only local formation at all resembling these deep-seated yellowish sands is the Lower Pliocene sands (with indurated layers) that form the plateau on which Adelaide is built, and have been penetrated, in well-sinking, by scores of business houses within the limits of the city. It was anticipated that the Lower Pliocene beds would underlie the Upper Pliocene marine formation for the following reasons. In the step-faulting of the Adelaide ranges towards the great downthrow on the westward side there is a step, or shelf, caused by a great fault-block slipping down about every 500 feet of vertical height. In illustration of this point see the accompanying diagram on page 29.

### Geological Section.

The Mount Lofty Ranges, in their typical development, may be taken to have an average height of about 2,000 feet, which represents the original peneplained surface of the country antedating the elevation of the ranges. The step-faulting, which was a concomitant of this elevation, settled in platforms at the following levels:—

- No. 1 Faulted-block formed the sloping platform of Upper Sturt, at an average height of 1,500 feet above sea level.
- No. 2. Ditto, formed the Blackwood-Belair platform, at 900 feet.
- No. 3. Ditto, the Adelaide-Mitcham platform, at 100-200 feet.
- No. 4. Ditto, caused a fracture of the Adelaide platform, with a downthrow of the broken segment, to 600 feet below sea level.

The fault-plane that caused the last-named displacement has a north and south direction; to the northward it follows the western side of the rounded scarp of Prospect, Enfield, Gepp's Cross, and passes between the Metropolitan Abattoirs bore and the Stockade; to the southward it follows the western parklands and passes between the Black Forest bore and Cowandilla bore. The boring was stopped at a critical level, geologically, and by an unfortunate mishap, as stated above, the material at this depth was not available for examination, information concerning which being limited to personal notes, made at the time by the Assistant Government Geologist (Mr. R. W. Segnit), but all the ascertained facts suggest that this very distinctive bed that occurs at the 600-feet level is the faulted Lower Pliocene from the Adelaide platform, and it was on this submerged shelf that the Upper Pliocene marine beds, as well as the overlying 400 feet of alluvium, were laid down. There can be little doubt that if the bore had been continued a few feet lower it would have penetrated the fossiliferous Miocene beds which underlie the Lower Pliocene of the Adelaide platform, as proved by the Black Forest and Kent Town bores and are at the surface in the banks of the River Torrens above Adelaide.




Geological Section.

## 5. Palaeontological.

During the deposition of the Adelaidean Upper Pliocene sediments there seems to have been an alternating action and reaction between the forces of the land and sea. It was only during the deposition of about 30 feet or 40 feet, as already stated, that normal marine conditions existed and marine life occurred *in situ* over the area. Throughout the rest of the deposits there was an almost total absence of conspicuous forms of life, the organic remains being limited to shell debris and to such forms of life as were of almost microscopic size, just such objects as might be transported by wind-action or gentle currents of water. The physical conditions were unstable. A base-level with a rising hinterland at the back, and oscillating sea margins in front, formed a somewhat indefinite borderland. The prevailing south-westerlies would carry the light material of the shore inland, and the streams, by lateral erosion, would carry along the waste from older fossiliferous systems that formed their banks. This seems to explain the incongruity of clear-water marine life, such as Polyzoa, being embedded in dense mud.

In the present paper the species recorded number, approximately, 38 foraminifera, 36 pelecypods, 26 gasteropods, and a promiscuous assemblage in various classes in smaller numbers. The foraminifera are generally plentiful, as to individuals, but limited as to species. They consist, mostly, of relatively common species of shallow water habit, more limited in variety than the present occurrences on our local beaches and in the Port Adelaide River [Howchin, W., 1890] and, in some species, they show a certain affinity with those found in the Miocene and Kalimnan beds at Muddy Creek, Victoria.

Among the more striking species of this class found in the Cowandilla bore is *Spiroloculina* aff. *arenaria* Br. [see *ante*, p. 4]. It has a coarse arenaceous test interspersed with black, shiny granules that give the test a speckled appearance. These black grains appear to have been obtained from the bed in which the shells are found, for similar grains are fairly abundant in the finer material. A few greenish pellets of glauconite occur in the material, but there seems no relationship between these and the black, shiny grains. The latter have some resemblance to certain forms of fish remains which take on this colour in a fossil condition. Can these minute granules represent the fossilized forms of the hard roes of fishes? These black particles are not all of a spherical form, but may be angular or flattened, suggesting other parts of a fish beside roes. If the black ingredients of the test were obtained from the sediments in which these foraminifera occur, it proves that the latter lived contemporaneously with its formation and are found *in situ*. A somewhat similar form, but destitute of a speckled test, has been figured by J. M. Flint ["Albatross" dredgings] off the coast of Florida; also by W. J. Parr [1932] from dredgings at Westernport Bay, Victoria. It is certainly distinct from Brady's species.

Another remarkable foraminiferal species, *Epistomella polystomelloides* [see *ante*, p. 6] occurs sparingly at a few horizons in the bore. It has a tropical and subtropical distribution, and is one of the species in the present bore that shows some relationship with the Muddy Creek fauna. The large and somewhat abundant *Elphidium* which possesses the numerous septation and umbilical prominences of *E. craticulatum* with the compressed form of *E. macellum*, also shows a remarkable modification of types, in this class, which has been noted in earlier pages.

The larger pelecypods, as *Ostrea hyotidoidea, Cucullaea corioensis, Eucrassatella kingicoloides, Miltha grandis*, and some others, occur at the level of the "oyster-bed" zone in all the bores within the Adelaide basin, but are not seen, except by occasional fragments, at other levels. The larger gasteropods are rare

and restricted. *Polinices subvarians* occurs, only, either as neanic or dwarfed specimens. The only others that could be mentioned are *Pelicaria howchini* and *Neodiastoma provisi,* both of which are limited to the "oyster" zone. The last-named is subjected to considerable variation. At the Dry Creek bore the examples have prominent longitudinal costae crossed by faint threads; in the present and other bores, the shells are slightly variced; while a specimen, obtained by the author from a small outlier at Marino, has the costae strongly cancellated; in some the sutures are slightly overlapped, while in the last-named specimen the sutures are deeply channelled. The large and highly ornate Cerithoid shell, first discovered from the Glanville bore, occurs again by two broken specimens in the present bore. It is believed to be a new species and is described here, in an Appendix, with a reproduced photograph, as pl. i.

The very minute shells that occur at depths where larger fossils are practically absent, such as *Austrosarepta (Lissarca) rubricata, Pronucula micans, Leda (Scaeoleda) verconis, Cyclostrema homalon, Cylichna pygmaea,* and others, all of which are living species in the adjacent sea, might easily be carried in a dry condition by the wind inland and mixed with fluviatile material in course of deposition; but this is not put forward as the sole cause of the abnormal distribution of the marine forms of life at different depths.

## APPENDIX.

### IV—Description of a New Cerithoid Fossil Shell.

*By Professor Walter Howchin and Bernard C. Cotton.*

**Terebralia adelaidensis,** n. sp.

[*Ref.,* Howchin, W., 1935, p. 90.]

Shell large, pyramidal, thick, sides slightly convex; adult whorls twelve, protoconch and early whorls absent; sculpture consisting of coarse irregularly spaced spiral sulcations numbering about twelve on the penultimate whorl; lower half of each whorl with raised, thick ribs, numbering ten on the penultimate whorl; aperture ovate, canal broken in all specimens, but apparently short; outer lip produced in front of the canal, below; apical angle 25°.

*Holotype.*—Upper Pliocene, Glanville Bore, Depth 375-400 feet. Length, 85 mm.; width, 27 mm. (Reg. No. D. 12852, S.A. Museum).

The species is related to the Recent *Terebralia palustris* Linn., which occurs in estuarine localities on the northern coasts of Australia. The coarse, raised longitudinal ribs and close spiral sulcations distinguish this fossil from the Recent shell. The holotype and four paratypes were selected by the senior author from the Glanville bore at a depth of 375-400 feet, as stated above. Two further specimens were procured from the Cowandilla bore.

The occurrence of this tropical genus in the Upper Pliocene of the Adelaide Basin suggests that subtropical conditions prevailed at that time in southern Australia.

In 1899 Tate described a large cerithoid fossil, based on two imperfect examples obtained from two well-sinkings on the Murray "Desert" [Plain]. This remarkable shell he named *Cerithium torrii,* estimating that, when complete, it would have a total length of 160 mm. [Tate, R., 1899, p. 109]. He remarks, "I do not know of any species of cerithoid shell, Recent or fossil, with which to compare *C. torrii.*" From the mixed nature of the fauna, Tate was in equal difficulty in determining the geological horizon of the deposits. He was impressed with the facies that many of the fossils bore to those found in the borings near

Adelaide. He states, "The fossils from the Murray Desert do not resemble those of any known locality yielding Older Tertiary fossils. But they do resemble those of the Pliocene beds in the Dry Creek and Croydon bores near Adelaide" [*loc. cit.*, p. 103]. The fine shell from the Glanville and Cowandilla bores, now described, is clearly distinct from the Murray Desert examples, especially in its particularized and ornate sculpture; but the two species can be closely associated in their common likeness to the characteristic estuarine group of shells so well known along the northern and north-eastern coast of Australia.

## V—ADDENDA TO THE MOLLUSCA OF THE GLANVILLE BORE.

By an oversight the following species were omitted from the list of the 375-400 feet sample of the Glanville bore:—

*Emarginula dennanti.* A complete shell of this species occurred at the above level.

*Nucula obliqua* Lamk. A single left valve in excellent preservation.

*Phylobrya* sp. One example.

*Saxicava arctica* Linné. One complete right valve, 15·5 mm. in length and 10 mm. in width. The surface is rough with prominent laminae.

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## DESCRIPTION OF PLATE I.

Fig. 1. *Terebralia adelaidensis,* n. sp. [Holotype], x 1·6.

Fig. 2. *Terebralia adelaidensis,* n. sp. [Paratype], x 1·6.

# SOME RED BASALTIC SOILS FROM EASTERN AUSTRALIA.

*BY J. A. PRESCOTT AND J. S. HOSKING*[1]

**Summary**

Notable for their natural fertility, the soils derived from basaltic rocks are amongst the first to be cleared and developed in eastern Australia. Their attractiveness to the settler is associated mainly with a high content of plant nutrients which render them independent of the need for artificial fertilisers, particularly superphosphate, during the early years of development, and in the case of the red soils is further associated with a loamy texture, rendering them readily permeable to water even in regions of high rainfall.

# SOME RED BASALTIC SOILS FROM EASTERN AUSTRALIA.

By J. A. Prescott and J. S. Hosking,[1] Waite Institute, University of Adelaide.

[Read April 9, 1936.]

Notable for their natural fertility, the soils derived from basaltic rocks are amongst the first to be cleared and developed in eastern Australia. Their attractiveness to the settler is associated mainly with a high content of plant nutrients which render them independent of the need for artificial fertilisers, particularly superphosphate, during the early years of development, and in the case of the red soils is further associated with a loamy texture, rendering them readily permeable to water even in regions of high rainfall.

Tertiary basalts giving rise to such soils are important in all the eastern States of Australia, from Queensland to Tasmania. They are unknown in South Australia, and are possibly only of importance in Western Australia in the Kimberley region. J. S. Hosking (1935[a]) has recently discussed a range of black earths derived from such basalts, and the present paper deals with the red soils. Only soils from Queensland and New South Wales will be discussed, although similar soils occur in Victoria and Tasmania. The latter are at present being studied from Hobart by Mr. C. G. Stephens.

The soils derived from basalt vary remarkably in character with the degree of pre-weathering and leaching that they have undergone, so that a range of soils, including red loams, peneplain laterites, brown earths, podsols, black earths, and chestnut earths is known to the authors. In Queensland, the close association between red loamy soils and basalt in the coastal areas is well recognised, but there are many characteristic red loams which cannot be related to basalts although popularly supposed to be so derived.

The soils investigated in the present instance were collected, principally, in 1928 by Mr. W. R. Winks, of the Queensland Department of Agriculture, and by arrangement with Professor R. D. Watt, of Sydney University. Owing to the absence of marked variations in the profile, the soils were sampled at the pre-arranged depths of 0–9, 9–18 and 18–27 inches. The soils fall within the zonal groups—red loams and red brown earths—principally the former. In Queensland, apart from the Clifton sample, where trees were scarce and stunted, the soils are associated with rain forest and the samples are taken from virgin country. Only one sample was available from the Atherton tableland, No. 1,253, from Malanda. Of the samples from New South Wales, that from Wollongbar is most closely related to the Queensland group. The remainder are from the plateau country away from the coast, and are associated with a much lower rainfall. The Guyra and Crookwell samples are associated with potato-growing. The Gunnedah sample was from a wheat farm cleared from savannah woodland, which type of vegetation was also characteristic of the samples from Bathurst and Glen Innes. The climatic conditions in each locality are given in Table II, where the sample sites are arranged in order from north to south.

## Mechanical Composition.

The mechanical analysis of the soils shows in general a remarkably high content of the clay fraction, in spite of which the soils possess an unusual degree of permeability which may be related to the chemical and mineralogical nature of

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[1] From the Division of Soils, Council for Scientific and Industrial Research.

the clay. Although it is not possible to distinguish any change in texture in descending the profile, in most cases the analyses show an increase in the clay content with depth. As will be seen from Table I, there is evidence from a consideration of such published analyses of the original parent basalt as are likely to be relevant, that the clay content of the soil is related to the felspar content of the rock as calculated by conventional methods from the chemical analysis.

TABLE I.

*Illustrating a possible Relationship between the Clay Content of the Soil and the Mineralogical Composition of the Parent Basalt.*

| Locality. | Orthoclase. | Albite. | Anorthite. | Total Felspars. | Clay in Dry Soil.* |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| Toowoomba - - - | 8·3 | 27·8 | 15·3 | 51 | 55 |
| Bathurst - - - | 8·9 | 21·5 | 28·1 | 58 | 54 |
| Tweed Heads (for Coolangatta) - | 12·8 | 29·9 | 19·2 | 62 | 69 |
| Burleigh Heads - - | 8·9 | 27·8 | 25·8 | 63 | 70 |
| Ballina (for Wollongbar) - | 10·6 | 28·3 | 25·0 | 64 | 63 |
| Montville - - - | 7·8 | 31·4 | 28·9 | 68 | 76 |

* Mean value to 27 inches depth.

The actual values for clay will be found in Table II, while the triangular diagram in fig. 1 gives a general survey of the whole data. It will be seen that the silt values vary from 10 to 25 per cent. of the mineral fraction of the soil.

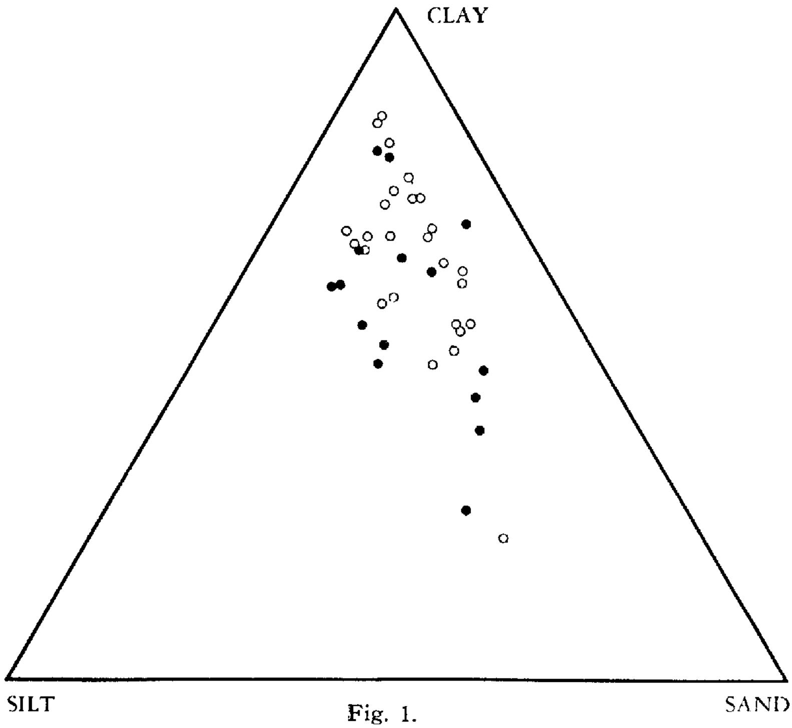


Fig. 1.

Triangular diagram illustrating mechanical analyses of red basaltic soils. Solid dots represent surface soils. Open circles represent subsoils.

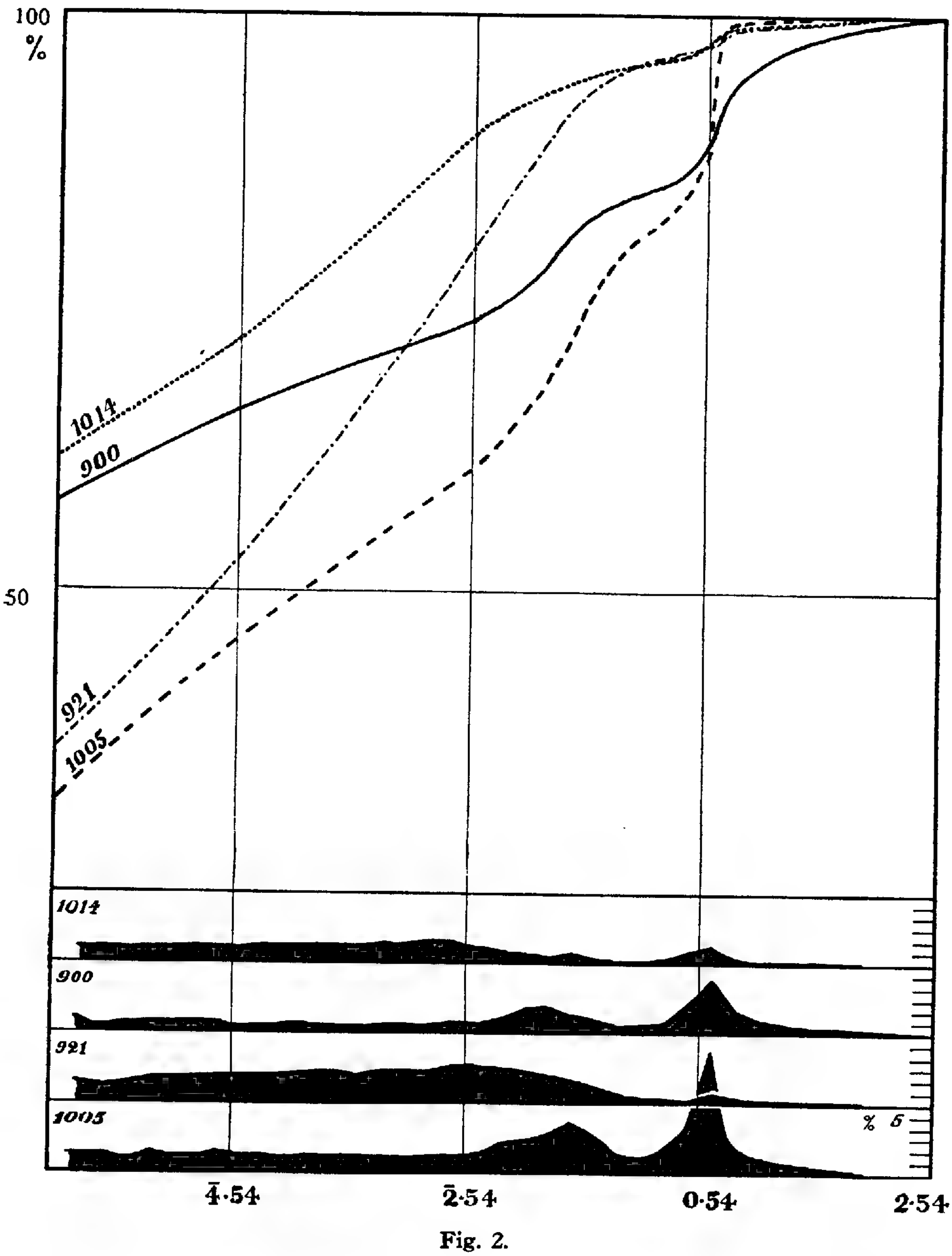


**Fig. 2.**

Summation curves of mechanical analyses of four typical soils:

900 Coolangatta — 1,005 Gunnedah
921 Toowoomba — 1,014 Wollongbar

In the lower part of the diagram are given the distribution curves derived from the above as percentages of the soil, allowing ten intervals to each of the three fractions, silt, fine sand and coarse sand. There is a relatively high frequency of particles around the diameter, 0·20—0·25 mm., just in the coarse sand fraction, with a subsidiary mode in the fine sand. The greatest frequency of clay particles occurs in the colloid zone beyond the margin of the diagram.

In a number of cases more detailed mechanical analyses were carried out by appropriate sieves and by allowing the prepared suspensions to settle for ten days. These suspensions were then sampled at a depth of 8·6 cm., giving log settling velocity of $\bar{5}$. From fig. 2 where four such analyses are given, it will be seen that there is relatively high frequency of particles of 0·20–0·25 mm. diameter with a less important mode in the fine sand fraction.

For one locality, Clifton, the fine sand fractions have been examined mineralogically by Miss D. Carroll (1932), who reports that the heavy fraction consists principally (up to 90 per cent.) of ilmenite. Leucoxene is absent, but rutile is conspicuous. Zircon and limonite are present, but subordinate. In the light fraction were present, quartz, orthoclose, plagioclase, kaolinised material and sponge spicules.

## Chemical Characteristics.

The soils were examined by standard methods of chemical analysis, and values for nitrogen, carbon, and for phosphoric acid and potash soluble in hydrochloric acid will be found in Table II. The ratio of carbon to nitrogen varies

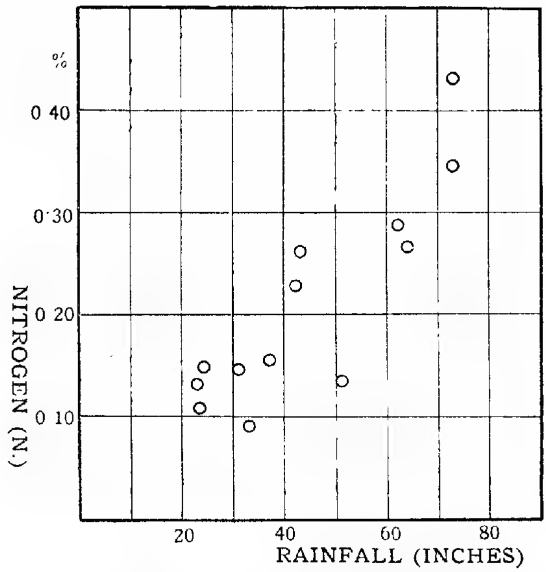


Fig. 3.

Relationship between rainfall and nitrogen content of soil.
Nitrogen figures are average values to a depth of eighteen inches.

from 8·4 to 21·1, with a maximum frequency between 14 and 15. The significance of these values and of the nature of the distribution curve has recently been discussed elsewhere, together with those for other groups of Australian soils (Hosking, 1935[(b)]). There is a general relationship between the organic matter content of the soil and the rainfall, best illustrated as in fig. 3 by the values for nitrogen. As the rainfall increases, so the native vegetation becomes more abundant, culminating in rain forest with correspondingly increased litter and a high nitrogen content of the soil.

The values for phosphoric acid are variable, as would be expected from the recognised variability of the parent rock in this respect. Apart from the samples from Gunnedah and Wellington Point, the values are satisfactory from the point of view of plant nutrition. Even these two exceptions are better than in the case

## TABLE II.

*Analyses of Red Basaltic Soils from Queensland and New South Wales.*

| Locality. | Rainfall, Inches. | Mean Temperature, °F. | Saturation Deficit. Inches of Mercury. | Depth of Sample, Inches. | Sample No. | On Air dry Soil. Nitrogen, % | Carbon % | $K_2O$ % | $P_2O_5$ % | Base Exchange Capacity to pH 8.4. m.e. per 100 gm. Soil. | Reaction, pH. | Clay,* % | Moisture Equivalent, % | In Clay. $\frac{SiO_2}{Al_2O_3}$ | $\frac{SiO_2}{R_2O_3}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QUEENSLAND— | | | | | | | | | | | | | | | |
| Malanda | ca. 60 | 68 | .18 | surface | 1253 | 0.19 | — | 0.08 | 0.32 | — | 6.0 | 56.0 | — | — | — |
| Bundaberg | 43 | 70 | .23 | 0–9 | 927 | 0.33 | 3.44 | 0.11 | 0.36 | — | 6.9 | 51.5 | 37 | 1.90 | 1.35 |
| | | | | 9–18 | 928 | 0.19 | 1.83 | 0.09 | 0.36 | — | 6.8 | 62.2 | 34 | — | — |
| | | | | 18–27 | 929 | 0.14 | 1.20 | 0.07 | 0.35 | 18.6 | 6.7 | 61.8 | 33 | 2.08 | 1.39 |
| Childers | 42 | 70 | .24 | 0–9 | 1312 | 0.30 | 4.27 | 0.22 | 0.13 | — | 6.3 | 53.8 | 31 | — | — |
| | | | | 9–18 | 1313 | 0.16 | 1.94 | 0.20 | 0.12 | 18.7 | 6.1 | 58.9 | 27 | 1.97 | 1.47 |
| | | | | 18–27 | 1314 | 0.10 | 1.19 | 0.14 | 0.16 | 15.3 | 5.0 | 57.8 | 27 | 1.99 | 1.49 |
| Montville | 62 | 67 | .18 | 0–9 | 903 | 0.40 | 5.81 | 0.04 | 0.20 | — | 5.1 | 59.8 | 46 | — | — |
| | | | | 9–18 | 904 | 0.17 | 2.60 | 0.04 | 0.17 | — | 5.0 | 67.7 | 45 | — | — |
| | | | | 18 27 | 905 | 0.07 | 1.30 | 0.03 | 0.15 | — | 4.9 | 64.0 | 48 | — | — |
| Toowoomba | 37 | 62 | .16 | 0–9 | 921 | 0.19 | 3.19 | 0.10 | 0.28 | 40.3 | 6.0 | 44.9 | 36 | 2.36 | 1.43 |
| | | | | 9–18 | 922 | 0.13 | 1.89 | 0.08 | 0.30 | 32.8 | 5.8 | 47.9 | 37 | 2.12 | 1.41 |
| | | | | 18–27 | 923 | 0.07 | 0.99 | 0.08 | 0.28 | 27.2 | 6.1 | 49.4 | 34 | 2.01 | 1.33 |
| Clifton | 23 | 63 | .20 | 0–9 | 906 | 0.14 | 1.97 | 0.12 | 0.22 | — | 6.3 | 68.5 | 33 | — | — |
| | | | | 9–18 | 907 | 0.08 | 1.08 | 0.11 | 0.16 | 28.0 | 6.3 | 73.9 | 37 | 2.05 | 1.56 |
| | | | | 18–27 | 908 | 0.05 | 0.59 | 0.10 | 0.13 | 26.1 | 6.8 | 75.0 | 37 | 2.13 | 1.57 |
| Wellington Point | 51 | 69 | .22 | 0–9 | 924 | 0.18 | 3.86 | 0.07 | 0.06 | — | 5.9 | 43.0 | 31 | — | — |
| | | | | 9–18 | 925 | 0.08 | 1.68 | 0.09 | 0.04 | — | 6.0 | 58.3 | 29 | — | — |
| | | | | 18–27 | 926 | 0.04 | 0.58 | 0.04 | 0.03 | — | 6.2 | 67.4 | 33 | — | — |
| Burleigh Heads | 73 | 66 | .20 | 0–9 | 897 | 0.62 | 7.31 | 0.15 | 0.30 | — | 6.4 | 47.0 | 42 | — | — |
| | | | | 9–18 | 898 | 0.24 | 3.26 | 0.12 | 0.19 | — | 5.5 | 61.0 | 37 | — | — |
| | | | | 18–27 | 899 | 0.12 | 1.62 | 0.09 | 0.16 | — | 5.2 | 66.9 | 39 | — | — |
| Coolangatta | 73 | 66 | .20 | 0–9 | 900 | 0.46 | 4.75 | 0.08 | 0.15 | 36.1 | 6.0 | 51.3 | 35 | 1.88 | 1.41 |
| | | | | 9–18 | 901 | 0.23 | 2.64 | 0.07 | 0.10 | 28.0 | 5.8 | 57.2 | 32 | 1.73 | 1.33 |
| | | | | 18–27 | 902 | 0.13 | 1.81 | 0.06 | 0.08 | 25.7 | 5.2 | 63.0 | 36 | 1.79 | 1.44 |
| NEW SOUTH WALES | | | | | | | | | | | | | | | |
| Wollongbar | 64 | 66 | .16 | 0–9 | 1014 | 0.34 | 3.93 | 0.11 | 0.36 | 28.4 | 5.4 | 51.4 | 32 | 1.21 | 0.68 |
| | | | | 9–18 | 1015 | 0.20 | 2.36 | 0.13 | 0.35 | 20.8 | 5.5 | 59.8 | 30 | 1.17 | 0.66 |
| | | | | 18–27 | 1016 | 0.09 | 1.44 | 0.14 | 0.34 | 18.6 | 5.4 | 63.4 | 31 | 1.25 | 0.71 |
| Glen Innes | 31 | 56 | .15 | 0–9 | 1002 | 0.19 | 2.77 | 0.29 | 0.19 | — | 6.5 | 39.8 | 44 | — | — |
| | | | | 9–18 | 1003 | 0.10 | 1.44 | 0.17 | 0.22 | — | 6.4 | 40.4 | 48 | — | — |
| | | | | 18–27 | 1004 | — | — | 0.14 | 0.27 | — | 6.8 | 18.3 | — | — | — |
| Gunnedah | 23 | 65 | .17 | 0–9 | 1005 | 0.18 | 2.49 | 0.91 | 0.09 | 48.1 | 7.5 | 40.1 | 33 | 3.43 | 2.67 |
| | | | | 9–18 | 1006 | 0.08 | 1.55 | 0.80 | 0.06 | 53.1 | 7.9 | 44.8 | 38 | 3.79 | 2.91 |
| | | | | 18–27 | 1007 | — | — | 0.78 | 0.05 | 57.9 | 8.1 | 52.8 | — | 3.67 | 2.85 |
| Bathurst | 24 | 57 | .13 | 0–9 | 1008 | 0.18 | 2.11 | 0.54 | 0.17 | 31.0 | 6.2 | 37.1 | 28 | 2.53 | 1.87 |
| | | | | 9–18 | 1009 | 0.12 | 1.42 | 0.53 | 0.15 | 36.4 | 6.5 | 60.3 | 38 | 2.48 | 1.91 |
| | | | | 18–27 | 1010 | 0.08 | 0.85 | 0.42 | 0.16 | 41.3 | 6.6 | 47.8 | 39 | 2.66 | 2.06 |
| Guyra | 35 | 53 | .15 | 0–9 | 1203 | 0.10 | 1.52 | 0.20 | 0.14 | 22.6 | 6.1 | 22.7 | 25 | 3.30 | 1.81 |
| Crookwell | 33 | 53 | .12 | 0–9 | 1011 | 0.11 | 1.25 | 0.40 | 0.36 | 30.2 | 6.1 | 34.3 | 28 | 3.19 | 2.02 |
| | | | | 9–18 | 1012 | 0.07 | 0.69 | 0.43 | 0.39 | 35.5 | 6.0 | 47.0 | 36 | 2.94 | 1.94 |
| | | | | 18–27 | 1013 | 0.06 | 0.47 | 0.34 | 0.38 | 46.2 | 5.9 | 44.4 | 43 | 2.98 | 1.97 |

*International values for clay corrected for organic matter retained.

of most Australian soils derived from other rocks. It must be remembered, however, that the presence of high amounts of free iron oxides in these soils is supposed to reduce the availability of the phosphoric acid and that separate standards are required for these basaltic soils.

The values for potash fall into two groups, depending on the degree of leaching and decomposition of the parent rock. The Queensland soils all show low values, particularly when viewed in relation to the clay content of the soil. The tableland soils of New South Wales are much richer, both absolutely and in relation to the clay content. A characteristic feature is the higher potash content of the surface horizons. Of the correlations examined, the ratio of potash to clay is inversely correlated with the rainfall and directly correlated with silica-alumina ratio of the clay. These correlations are not, however, very high.

The soil reaction was determined by means of the antimony electrode, using a ratio of soil to water of 1 to 2·5. None of the soils is strikingly acid, except that from Montville, where the low potash content also indicates considerable leaching. The sample from Gunnedah, a red-brown earth rather than a red loam, is alkaline in reaction and has also the highest potash content as well as the highest silica-alumina ratio.

On a number of the samples, exchangeable hydrogen to pH 8·4 was determined for us by Mr. C. S. Piper (1936) of this laboratory, using the equilibrium between a suspension of the soil in a solution of meta nitro phenol for this purpose, developed from the methods of Schofield (1933).

The sum of exchangeable bases and of this exchangeable hydrogen gives a measure of the base exchange capacity of the soil when in equilibrium with calcium carbonate under atmospheric conditions. The values recorded in Table II are reviewed in a subsequent section in relation to the chemical composition of the clay fraction.

### Exchangeable Bases.

The exchangeable bases, together with exchangeable hydrogen, as noted above, are recorded in Table III. Soils from ten localities only were examined, and all show the Australian characteristic of high values for magnesium. The values for exchangeable hydrogen should be examined in relation to the pH values given in Table II. Taking into consideration the clay content of the soil and the organic carbon, the total base exchange capacity was divided between the clay and the carbon values. In a number of profiles, notably Childers, Toowoomba, Clifton, Coolangatta, and Wollongbar, a satisfactory distribution could be obtained by simple algebraic methods, and the mean of the values for the organic carbon so obtained, namely 512 milligram equivalents per 100 gm. carbon was used in the case of the remaining soils. These values should be compared with that of 455 obtained by Rice Williams (1932), and a mean of 623 obtained by Slater and Byers (1934). Allowing for the exchange capacity of the organic matter in this way, the residual exchange capacity due to the clay was calculated, giving values ranging from 17·1 to 100·2 milligram equivalents per 100 gm. of clay. This wide range is associated with the chemical character of the clay, and of a number of possible correlations, the highest ($R = 0{\cdot}90$) was found between the exchange capacity and the silica-alumina ratio. This relationship is illustrated in fig. 4.

The relationship between base exchange capacity and silica-alumina ratio has been previously discussed by Rice Williams (1932), who found no evidence of such with his range of soils, mostly from Wales. He obtained a mean value of 57 m.e. per 100 gm. of clay under conditions similar to those discussed above, namely equilibrium with calcium carbonate. Crowther and Basu (1931) obtained a corresponding value of 61 for the Woburn soils. Slater and Byers (1934), with colloids extracted from a wide range of soils from the erosion stations of

TABLE III.

*Exchangeable Bases in Red Basaltic Soils.*

| Locality. | Sample No. | Total Bases m.e. | Proportion as Ca. | Mg. | K. | Na. | Exchangeable Hydrogen to pH 8·4 | Exchange Capacity per 100 gm. Clay. | Exchange Capacity per 100 gm Organic Carbon. |
|---|---|---|---|---|---|---|---|---|---|
| Bundaberg .... | 927 | 23·3 | 75 | 21 | 3 | 1 | — | — | |
| | 928 | 14·3 | 72 | 24 | 3 | 1 | — | — | |
| | 929 | 11·3 | 69 | 27 | 2 | 2 | 7·3 | 20·1 | (512) |
| Childers .... | 1312 | 19·6 | 69 | 23 | 7 | 1 | — | — | |
| | 1313 | 9·6 | 64 | 27 | 6 | 3 | 9·1 | 17·8 | 423 |
| | 1314 | 4·3 | 54 | 33 | 7 | 6 | 11·0 | 17·5 | |
| Toowoomba .. | 921 | 23·0 | 63 | 34 | 2 | 1 | 17·3 | 41·6 | |
| | 922 | 13·8 | 53 | 44 | 1 | 2 | 19·0 | 41·8 | 673 |
| | 923 | 12·0 | 46 | 51 | 1 | 2 | 15·2 | 41·5 | |
| Clifton .... .... | 906 | 16·0 | 55 | 41 | 1 | 3 | — | — | |
| | 907 | 17·2 | 48 | 48 | 1 | 3 | 10·8 | 31·3 | 463 |
| | 908 | 18·5 | 45 | 50 | 1 | 4 | 7·6 | 31·3 | |
| Coolangatta .. | 900 | 18·8 | 58 | 34 | 4 | 4 | 17·3 | 20·4 | |
| | 901 | 11·5 | 42 | 48 | 4 | 6 | 16·5 | 24·1 | 538 |
| | 902 | 7·2 | 38 | 49 | 5 | 8 | 16·5 | 22·2 | |
| Wollongbar .. | 1014 | 7·7 | 55 | 37 | 6 | 2 | 20·7 | 20·8 | |
| | 1015 | 5·1 | 53 | 36 | 7 | 4 | 15·7 | 17·1 | 452 |
| | 1016 | 5·0 | 46 | 43 | 7 | 4 | 13·6 | 19·1 | |
| Gunnedah .... | 1005 | 45·7 | 72 | 22 | 6 | 0 | 2·4 | 88·1 | |
| | 1006 | 52·6 | 70 | 26 | 3 | 1 | 0·5 | 100·2 | (512) |
| | 1007 | 57·6 | 64 | 32 | 2 | 2 | 0·3 | — | |
| Bathurst .... | 1008 | 20·7 | 54 | 37 | 8 | 1 | 10·3 | 55·2 | |
| | 1009 | 23·9 | 51 | 45 | 3 | 1 | 12·5 | 48·2 | (512) |
| | 1010 | 31·5 | 48 | 49 | 2 | 1 | 9·8 | 76·9 | |
| Guyra .... .... | 1203 | 14·2 | 66 | 26 | 6 | 2 | 8·4 | 64·9 | (512) |
| Crookwell ... | 1011 | 17·6 | 54 | 37 | 8 | 1 | 12·6 | 69·4 | |
| | 1012 | 22·4 | 52 | 42 | 5 | 1 | 13·1 | 68·0 | (512) |
| | 1013 | 31·3 | 50 | 46 | 3 | 1 | 14·9 | 99·0 | |

the United States, obtained relationships closely parallel to those obtained in the present work, as are also those obtained by Mattson (1926). The American workers, however, had a different end point for base exchange capacity in the neighbourhood of pH 7.

It may be pointed out that a correlation coefficient of 0·90, while implying a general relationship, is not sufficiently high for discussion of physico-chemcial problems. It will be noted that for a silica-alumina ratio of 2·0 in fig. 4, a range of from 18 to 41 milli-equivalents is to be observed in the exchange capacity in spite of the uniform origin of the parent material. Recent discussions by Marshall (1935) suggest that not until the mineralogcial composition of the clay has been determined will a more completely satisfying relationship be obtained.

## CHEMICAL ANALYSIS OF CLAY FRACTION.

From those soils on which base exchange relationships had been obtained, the clay fraction was separated by preliminary dispersion and repeated decantion. In order to avoid possible decomposition of the clay by acid treatment, the dispersion methods used were those advocated by Puri (1930, 1935), involving treatment with sodium chloride, or boiling with ammonium carbonate followed by sodium hydroxide where the first method was not sufficiently effective. The time

of sedimentation was 24 hours in a depth of 8·6 cm., the old British standard on which much previous clay analysis has been based. The separated clay was flocculated with calcium chloride, filtered and washed with alcohol. There is a tendency for some calcium carbonate to remain in the clay. The clays also contain some organic matter. They were analysed by fusion with sodium carbonate in accordance with standard mineralogical practice, the tri-acid method advocated by R. C. Groves (1933) having been found to be only occasionally reliable with these clays.

The results of the analyses are given in Table III. In addition to the ordinary determinations, an estimate of the free iron oxide was attempted following the

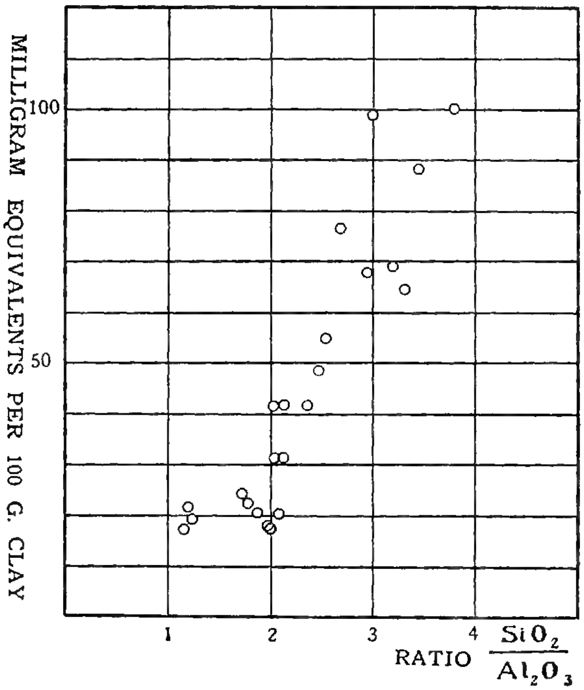


Fig. 4.

Relationship between the molecular ratio of $SiO_2$ to $Al_2O_3$ of the clay and the base exchange capacity of basaltic soils at pH 8·4.

procedure of Drosdoff and Truog (1935). While these results are not to be considered as final, they are of the correct order of magnitude. Of the iron oxide present in the clay, from 35 per cent. to 85 per cent. is present in the free state. The values for titanium are relatively high, and it would be of interest to speculate on its state of combination. In view of the predominance of ilmenite in the heavy minerals of the fine sand fraction, possibly some may be present in these clays. Such ilmenite would further reduce the amount of iron oxide combined with silica.

The molecular ratios of silica to alumina and of silica to sesquioxides have been calculated and will be found in Table II. There is a general relationship between rainfall and the ratio, the higher the rainfall the lower the ratio. The Clifton samples afford a notable exception. This characteristic red loam is out of keeping with the local climatic conditions, and the soil characteristics may have been imposed in a previous climatic cycle of greater rainfall.

## Relationship between Physical Properties and Nature of the Clay Fraction.

It is well recognised that the basaltic red loams possess favourable physical properties in the field entirely out of keeping with the amount of clay present. As a measure of the physical properties, both sticky points and moisture equivalents were determined on a number of these soils, and the results have already been discussed elsewhere by Prescott and Poole (1934). In general, a close correlation between sticky point and moisture equivalent was observed, but when compared with other Australian soils the moisture equivalents were low for the corresponding sticky points. The multiple correlation between moisture equivalent and clay, silt and organic matter, was not so satisfactory as in the case of other groups of soils examined at the time. The examination of these soils, both with respect to exchange capacity and with respect to the composition of the clay fraction, afforded an opportunity of reconsidering the data for moisture equivalent previously obtained. An allowance of 130 per cent. was made with respect

Table IV.

*Analyses of Clays Separated from Red Basaltic Soils.*

| Locality. | Sample No. | $SiO_2$ %. | $Al_2O_3$ %. | $Fe_2O_3$ %. | Free $Fe_2O_3$ %. | $TiO_2$ %. | Loss on Ignition %. | Moisture %. | Ratio $\frac{\text{Free } Fe_2O_3}{\text{Total } Fe_2O_3}$ |
|---|---|---|---|---|---|---|---|---|---|
| Bundaberg .... | 927 | 22·33 | 19·79 | 12·81 | — | 1·98 | 24·12 | 2·30 | — |
| | 929 | 31·65 | 25·72 | 20·20 | 17·25 | 2·38 | 14·05 | 3·12 | ·85 |
| Childers .... | 1313 | 30·22 | 26·15 | 13·65 | 7·95 | 1·80 | 17·40 | 2·48 | ·58 |
| | 1314 | 32·22 | 27·40 | 14·49 | 9·37 | 1·81 | 15·45 | 2·67 | ·65 |
| Toowoomba .. | 921 | 28·85 | 20·79 | 21·35 | 12·28 | 2·71 | 17·44 | 6·24 | ·58 |
| | 922 | 31·02 | 24·80 | 19·85 | 11·56 | 2·22 | 15·10 | 5·80 | ·58 |
| | 923 | 30·55 | 25·96 | 20·35 | 12·32 | 2·59 | 13·60 | 5·36 | ·60 |
| Clifton .... .... | 907 | 33·32 | 27·63 | 13·75 | 7·03 | 1·24 | 15·38 | 4·83 | ·51 |
| | 908 | 32·02 | 25·51 | 14·33 | 7·12 | 1·38 | 15·46 | 5·01 | ·50 |
| Coolangatta .. | 900 | 25·17 | 22·79 | 11·88 | 6·89 | 1·53 | 23·81 | 4·47 | ·58 |
| | 901 | 27·60 | 27·09 | 11·50 | — | 1·61 | 20·20 | 4·20 | — |
| | 902 | 30·61 | 29·81 | 11·00 | 5·35 | 1·51 | 18·42 | 3·04 | ·50 |
| Wollongbar .. | 1014 | 17·30 | 24·21 | 29·70 | 10·24 | 2·71 | 19·85 | 1·95 | ·35 |
| | 1015 | 15·72 | 22·84 | 27·60 | 11·25 | 2·46 | 20·35 | 2·20 | ·41 |
| | 1016 | 18·20 | 24·77 | 29·60 | 14·28 | 2·58 | 17·47 | 2·28 | ·49 |
| Gunnedah .. .. | 1005 | 42·10 | 20·78 | 9·23 | 5·82 | 0·94 | 13·04 | 8·30 | ·63 |
| | 1006 | 43·95 | 19·64 | 9·21 | 4·96 | 0·87 | 10·84 | 9·79 | ·54 |
| | 1007 | 43·22 | 19·92 | 9·02 | 4·94 | 0·81 | 10·59 | 9·54 | ·55 |
| Bathurst .... | 1008 | 36·27 | 24·24 | 13·45 | 8·50 | 1·26 | 15·78 | 5·57 | ·63 |
| | 1009 | 37·44 | 25·59 | 11·92 | 7·16 | 0·95 | 14·03 | 6·54 | ·60 |
| | 1010 | 38·45 | 24·47 | 11·41 | 6·03 | 0·99 | 13·84 | 7·06 | ·53 |
| Guyra .... .... | 1203 | 33·35 | 17·18 | 22·00 | 14·35 | 4·47 | 13·87 | 5·51 | ·65 |
| Crookwell .. | 1011 | 35·80 | 19·07 | 17·32 | 8·64 | 2·66 | 13·16 | 6·80 | ·50 |
| | 1012 | 36·02 | 20·86 | 16·86 | 8·98 | 1·80 | 11·66 | 8·12 | ·53 |
| | 1013 | 36·62 | 20·93 | 16·56 | 8·35 | 1·61 | 11·42 | 8·49 | ·50 |

to organic matter, and 30 per cent. with respect to silt, the residual moisture equivalent being allotted to the clay. In this way values for the moisture equivalent per 100 gm. of clay were calculated, and the values so obtained plotted against various other constants calculated for these clays. There is a good correlation between the silica-alumina ratio and the moisture equivalent, but a somewhat better one between exchange capacity and moisture equivalent ($R = 0{\cdot}887$). No improvement of this correlation would on inspection appear to be possible by allowing for the free iron oxide in the clay, for the pH values of the soil or for

the proportion of replaceable sodium and potassium. The factors in the clay, therefore, that make for high base exchange capacity, also make for high moisture equivalent, and the favourable physical characteristics of these soils may, therefore be related to chemical composition of the clays.

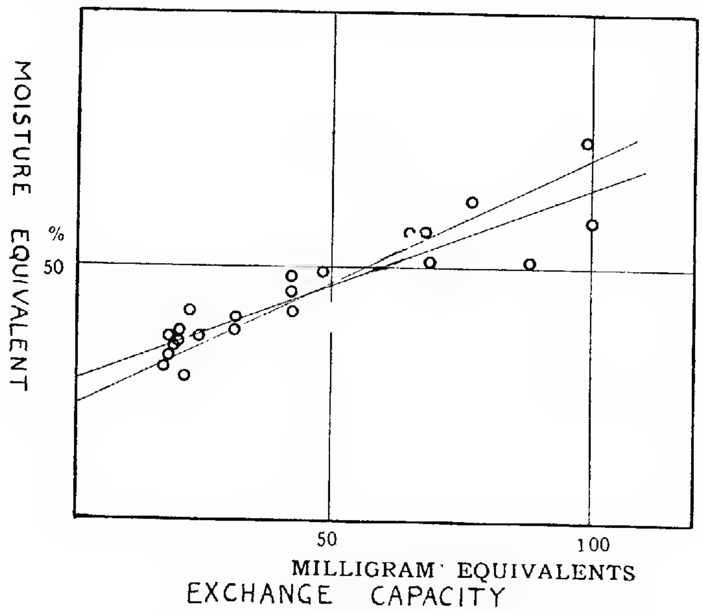


Fig. 5.

Illustrating the relationship between the moisture equivalent and exchange capacity per 100 gm. of clay. Calculated from soil values after allowing for organic matter and silt in the case of moisture equivalent, and for organic carbon in the case of exchange capacity.

The relationship between moisture equivalent and base exchange capacity is illustrated in fig. 5, where the regression lines have also been drawn. It is of interest to note that with clay of no exchange capacity, there is still a moisture equivalent of 25 per cent., which is near the value of 30 already assumed for the silt fraction of these soils.

## Summary.

The chemical and physical characteristics of a series of red soils from Queensland and New South Wales derived from tertiary basalts are discussed. The soils fall into two groups: (1) red loams, associated generally with coastal rain forests; (2) red brown earths, associated with the lower rainfall of the plateau country of New South Wales.

The clay content of the soils is higher than would be expected from field considerations and appears to be correlated with the felspar content of the original basalt. Values for total nitrogen, carbon, phosphoric acid and potash, and for exchangeable bases and exchangeable hydrogen, are recorded and discussed. The soils vary in degree of acidity, but are rarely very acid.

Relationships between moisture equivalent, exchange capacity and composition of the clay fraction are examined. There is a notable correlation between the exchange capacity calculated per 100 gm. of clay and the silica-alumina ratio of the clay. A close relationship between exchange capacity and moisture equivalent is also indicated.

An appreciable proportion of the iron oxide occurring in the clay fraction is in a free state.

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# ADELAIDE UNIVERSITY FIELD ANTHROPOLOGY, CENTRAL AUSTRALIA.
# NO. 13-ANTHROPOMETRIC OBSERVATIONS ON SOUTH AUSTRALIAN ABORIGINES OF THE DIAMANTINA AND COOPER CREEK REGIONS.

*BY FRANK J. FENNER*

**Summary**

The observations recorded in this paper form part of the systematic work done on the tenth Anthropological Expedition to Central Australia, carried out under the direction of the Board of Anthropological Research, University of Adelaide. The expenses of the expedition were mainly covered by funds made available by the Rockefeller Foundation, through the Australian National Research Council. The party made its base camp at Pandi Pandi, on the Diamantina River, and also worked at Mirra Mitta during August, 1934.

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[Read April 9, 1936.]

Plates II. and III.

The observations recorded in this paper form part of the systematic work done on the tenth Anthropological Expedition to Central Australia, carried out under the direction of the Board of Anthropological Research, University of Adelaide. The expenses of the expedition were mainly covered by funds made available by the Rockefeller Foundation, through the Australian National Research Council. The party made its base camp at Pandi Pandi, on the Diamantina River, and also worked at Mirra Mitta during August, 1934.

The approximate boundaries of the territories of the various aboriginal tribes of north-eastern South Australia are indicated in fig. 1, which was constructed from information kindly supplied by N. B. Tindale, the ethnologist of the South Australian Museum. Members of the tribes, the names of which are underlined in the map, were measured at Pandi Pandi and Mirra Mitta. It can be seen that aborigines from a very large area have drifted together into a few cattle stations, from which they were gathered to Pandi Pandi and Mirra Mitta in August, 1934. Several of the individuals examined were the last remaining members of their respective tribes.

*Natives examined.*—Of the fifty or more surviving members of the tribes of the Central and Eastern Lake Eyre Basin, detailed anthropometric observations were carried out on forty-one full-bloods. Owing to physical and other disabilities there were a few full-bloods to whom anthropometric methods could not be applied, while the measurements of several half-castes and three-quarter castes are omitted from this series.

The natives in question are "station blacks" living in a semi-civilized condition and receiving rations from the Government; in addition to which some of the men work as stockmen and some of the women as domestics. All are accustomed to wearing European clothing, and, as they were loth to discard all their garments, the identification of certain of the bony points was difficult. The names, approximate ages, and tribal groups of the individuals examined in detail are set out in Table I. The ages were estimated by three members of the party, working on the bases of physical appearance, dental condition, and social relationships, respectively. These estimates were correlated and the final decision embodied in the table. Concerning Arinjanpika (B) [1] and Akawiljika (EE), Mr. L. Reese, of Minnie Downs, who greatly assisted the expedition at Pandi Pandi, was able to supply the exact ages.

*Measurements recorded.*—The key numbers to the measurements made are given in Table II. The majority of these measurements are in accordance with the definitions of the International Agreement, Hrdlicka (1). Those not thus

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[1] In native words the letter *j* represents the soft *y* sound as in yacht.

defined, *viz.*, Nos. 9, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, and 38 of Table II, have been made in accordance with the definitions of F. Wood Jones (2) [P. 15 (42). P. 16 (57, 59, 62, 66, and 69). P. 17 (71, 73, 74, 75, and 76). P. 23 (17), respectively]. All linear measurements are in millimetres, and weights are recorded as kilograms. Where the features are bilateral, the measurements of the left-hand side only have been recorded.

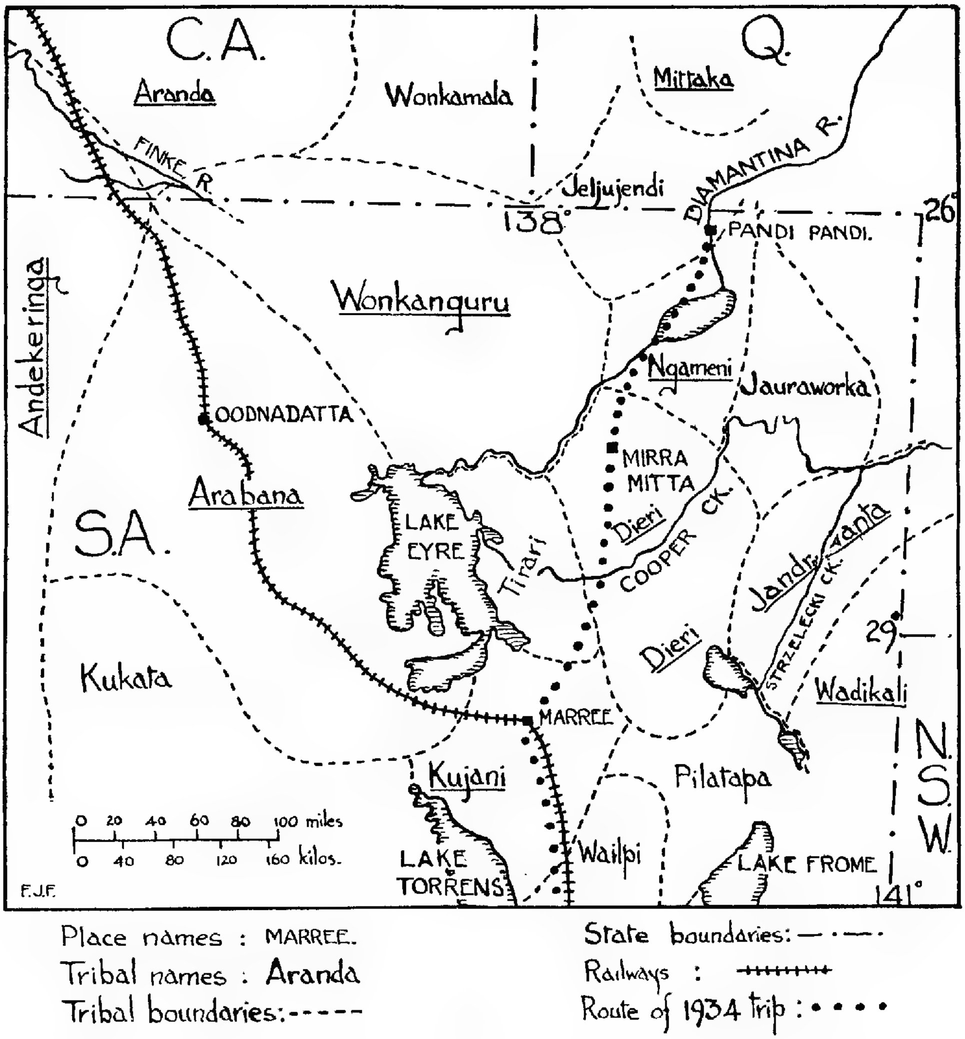


Fig. 1.

The experience gained in the field work embodied in these records supports the opinions expressed by Wood Jones and Campbell (3), and Campbell and Lewis (4), that under the existing field conditions the determination of certain of the bony landmarks, for instance the trochanterion and symphysion, is at best approximate and at worst so inexact that the resulting measurements are of very doubtful value.

*Instruments used.*—As on previous expeditions Martin's anthropometric set was used; this consists of a stature rod, spreading calipers and sliding compasses.

A metallic millimetre tape, Parson's radiometer, and a pelvimeter (graduated in centimetres only) were also used. Weights were determined on a spring balance suspended from a tree, deductions being made for the weight of clothing.

From the experience gained during several expeditions, modifications have been made to the stature rod. These ensure a firm horizontal base and a vertical rod. Figure 2 shows the apparatus assembled for use, the board and pantograph projecting from the upright being a contrivance for the determination of spinal curves.

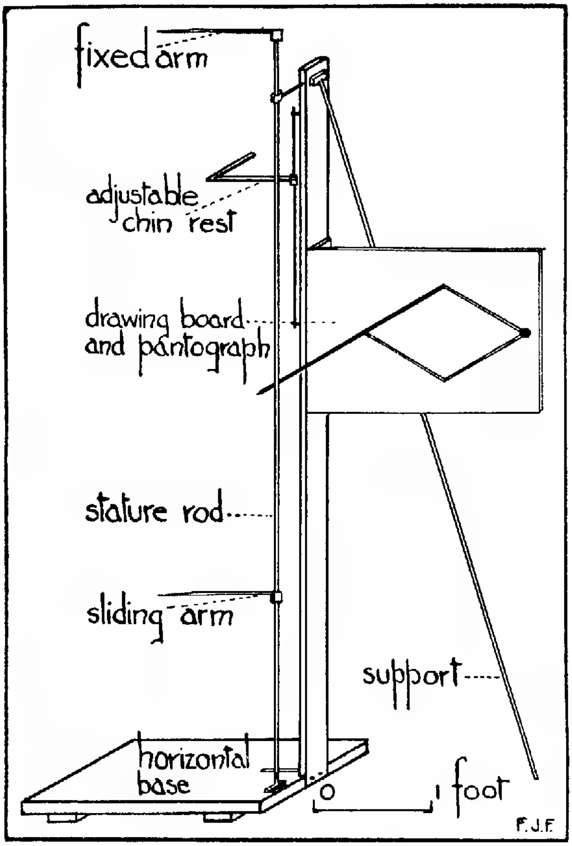


Fig. 2.

*Data recorded.*—The results of the anthropometric work are summarized in Table III, the key letters indicating individuals, and the key numbers indicating measurements (see Tables I and II). The indices derived from these measurements are given in Table IV. In order to avoid confusion and uncertainty, care has been taken to refer each index to its exact definition, the reference numbers in Table IV alluding to the page and number of the formula used, as given by F. Wood Jones (2).

In determining mean values for measurements and indices, individuals *a, b, c,* and *d,* who were not fully developed, were excluded from the series, although their actual measurements have been placed on record in Table III. Separate mean values have been worked out for males (A to T) and females (AA to PP).

Standard portraits, some of which are reproduced in plates II and III, were taken by N. B. Tindale, who also made an ethnographic record of each individual. The various data collected in Table I have been compiled from these records.

*General Summary.*—During the last nine years, annual expeditions organised by the Board of Anthropological Research of the Adelaide University have been making systematic records of the physical anthropology of the Australian aborigine. The early results of this work were published in the Transactions of the Royal Society of South Australia (4) (5). Records made in the interval between 1928 and 1933 have been incorporated in a monograph shortly to be published. The field work, which forms the basis of this paper, was done after the manuscript of that monograph was completed.

The number of individuals examined is too small to draw any definite conclusions from these records. However, a brief description can be extracted from these and previous tables of the physical proportions of the Central Australian aborigines. Their physical characteristics are well defined and appear constant from group to group. There is a considerable individual variation; for instance, the extremes of the value of the cephalic index in the group dealt with in this paper are 83·5 (JJ) and 64·5 (J). The physical characteristics which can be derived from measurements may be summarized as follows:—

*Body and limb proportions* (compared with European standards):—

Slightly less than "average human height" (1,650 mms., Topinard).
The limbs are long relative to the trunk.
The distal segments of the limbs are unusually long.
The shoulders and chest are carried high.
The hands are long and narrow.

*Head and face*:—

The head is long—dolichocephalic.
The face is rather broad.
The supraorbital ridges are prominent and the eyes deep set.
The nose is widespread and flattened at the bridge.
The lips are moderately full.
The ears are large, well shaped, and about twice as long as they are broad.

An inspection of the plates will confirm the impressions derived from a study of the measurements. The portraits also show other typical features of the physiognomy of the Australian aborigine, notably the sloping forehead, the prognathism, and the "beetling brow" of the males, which are not obvious from a study of the measurements alone.

## Note on the Mortality of the Natives.

Information subsequently received from Mr. Reese and from Mr. G. Aiston, of Mulka (January, 1936), indicates that since August, 1934, when the records were made, thirteen of the natives of that area have died. Besides those indicated in Table I, the following are now dead:—Sandy, who was measured at Macumba [No. 1 of the series of Campbell and Hackett, 1927 (5) ]; Oscar, who was not measured; the daughters of Aida (NN) and Clara (BB); the babies of Dorisi (HH) and Esther (II); and an old gin (unspecified). This means that in eighteen months 20 per cent. of the aboriginal population of the Central and Eastern Lake Eyre Basin have died. Moreover, four of these were children, and several of the others were young men and women. These figures force home the realization of the very rapid disappearance of the Australian aborigine, when once he has been detribalized and has degenerated to a hanger-on on the cattle stations.

TABLE I.

| *Subject. | | Sex. | Age. | Native Name. | European Name. | Tribal Group. |
|---|---|---|---|---|---|---|
| A | (J3) | Male | 45 | Arupalondika | Jimmy Naylon | Wonkanguru |
| B | (J7) | „ | 29 | Arinjanpika | Johnny Reese | „ |
| C | (J10) | „ | 50 | Warukili | Mungarannie Mick | Jandruwanta |
| D | (J12) | „ | 25 | Djitjibui | George | Andekeringa |
| E | (J19) | „ | 22 | Pokkawinna | Arthur | Wonkanguru |
| †F | (J23) | „ | 50 | Injili Witturu | Pandi Mick | „ |
| G | (J24) | „ | 37 | Juruli | Walter Naylon | „ |
| H | (J25) | „ | 50 | Injili Parubata | Jimmy | „ |
| I | (J26) | „ | 47 | Djeigina | Arunta Mick | Andekeringa |
| J | (J31) | „ | 30 | Mendjina | Jimmy Finn | „ |
| K | (J32) | „ | 45 | Paputooka | Finke Bob | Aranda |
| †L | (J38) | „ | 50 | Pidia | Leslie Pondi | Kujani |
| M | (J44) | „ | 50 | — | Johannes | Arabana |
| N | (J47) | „ | 23 | Wangpulu | Les Russell | Dieri |
| O | (J48) | „ | 45 | Tankaijuna | Tommy Lumpkins | Wonkanguru |
| P | (J1) | „ | 75 | Njira | Taffy | Mittaka |
| †Q | (J2) | „ | 60 | Tintibanna | Sam | Dieri |
| R | (J8) | „ | 65 | Tenpili | Nipper | Ngameni |
| S | (J13) | „ | 70 | Ngaltjagintata | Old Billy | Aranda |
| T | (J46) | „ | 75 | Palpilinna | Ned | Wadikali |
| AA | (J4) | Female | 45 | Karatjarni | Lizzie | Wonkanguru |
| BB | (J5) | „ | 19 | Keidanankara | Clara | „ |
| CC | (J9) | „ | 50 | Kakuluru | Sarah | „ |
| DD | (J14) | „ | 40 | Ngalijuru | Topsy | „ |
| EE | (J16) | „ | 48 | Akawiljika | Maudie | „ |
| FF | (J20) | „ | 33 | Ekewiljika | Topsy | „ |
| GG | (J21) | „ | 35 | Kappina | Topsy | „ |
| †HH | (J34) | „ | 19 | — | Dorisi | „ |
| II | (J35) | „ | 33 | — | Esther | „ |
| JJ | (J41) | „ | 33 | — | Florrie | Dieri |
| KK | (J15) | „ | 72 | Minimini | Lucy | Wonkanguru |
| LL | (J27) | „ | 60 | Tarangoju | Nancy | „ |
| MM | (J29) | „ | 60 | — | Maggie | „ |
| †NN | (J40) | „ | 55 | Mingipani | Aida | „ |
| OO | (J42) | „ | 18 | — | Alice | „ |
| PP | (J45) | „ | 18 | — | Olga | Arabana |
| *a* | (J33) | Male | 17 | Kanpili | Tommy Naylon | Wonkanguru |
| †*b* | (J18) | Female | 15 | Tjilkeila | Nellie | „ |
| *c* | (J22) | „ | 15 | — | Thea | Aranda |
| *d* | (J11) | „ | 7 | — | Linda | Wonkanguru |

*The figures in parentheses are the original key numbers which appear in all the records of the expedition, J being the key letter for this trip.

†Indicates that the subject has died since examination.

TABLE II.

| | | | | | |
|---|---|---|---|---|---|
| Body | 1. | Stature | Foot | 24. | Foot length |
| | 2. | Sitting height | | 25. | Foot breadth |
| | 3. | Height to suprasternal notch | Head | 26. | Length |
| | 4. | Height to chin | | 27. | Breadth |
| | 5. | Height to shoulder | | 28. | Height |
| | 6. | Bihumeral breadth | Face. | 29. | Height gnathion crinion |
| | 7. | Biacromial breadth | | 30. | Height gnathion nasion |
| | 8. | Arm span | | 31. | Height gnathion stomion |
| | 9. | Biaxillary diameter | | 32. | Diameter minimum frontal |
| | 10. | Transverse chest diameter | | 33. | Diameter maximum bizygomatic |
| | 11. | Anteroposterior chest diameter | | 34. | Diameter maximum bigonial |
| | 12. | Bispinal diameter | | 35. | Maximum interorbital |
| | 13. | Bicristal diameter | | 36. | Maximum intercanthal |
| | 14. | Bitrochanteric diameter | | 37. | Minimum intercanthal |
| | 15. | Weight | | 38. | Bi-orbito-nasal arc |
| Arm | 16. | Length of the upper limb | Nose | 39. | Length |
| | 17. | Length of arm | | 40. | Height |
| | 18. | Length of forearm | | 41. | Breadth |
| Hand | 19. | Length | | 42. | Prominence |
| | 20. | Breadth | Mouth | 43. | Breadth |
| Leg. | 21. | Length of the lower limb | | 44. | Bilabial height |
| | 22. | Length of thigh | Ear | 45. | Length |
| | 23. | Length of leg | | 46. | Breadth |

TABLE III A.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1672 | 843 | 1379 | 1465 | 1376 | 407 | 379 | 1820 | 250 | 260 | 190 | 240 | 270 | 290 | 64.3 | 776 | 335 | 281 | 179 | 79 | 883 | 399 | 423 |
| B | 1695 | 820 | 1412 | 1483 | 1407 | 410 | 358 | 1835 | 235 | 250 | 170 | 200 | 240 | 270 | 55.0 | 820 | 325 | 299 | 199 | 83 | 931 | 439 | 430 |
| C | 1678 | 817 | 1381 | 1452 | 1381 | 410 | 374 | 1790 | 270 | 280 | 180 | 210 | 250 | 290 | 60.0 | 767 | 313 | 281 | 180 | 75 | 902 | 438 | 407 |
| D | 1710 | 855 | 1427 | 1487 | 1413 | 435 | 387 | 1797 | 280 | 280 | 205 | 240 | 270 | 320 | 62.6 | 745 | 323 | 245 | 185 | 87 | 864 | 384 | 423 |
| E | 1679 | 844 | 1395 | 1464 | 1423 | 380 | 351 | 1810 | 250 | 230 | 170 | 220 | 230 | 280 | 47.5 | 798 | 356 | 260 | 191 | 75 | 910 | 460 | 398 |
| F | 1700 | 807 | 1409 | 1459 | 1377 | 424 | 371 | 1782 | 250 | 260 | 190 | 240 | 270 | 300 | 65.0 | 776 | 341 | 250 | 187 | 62 | 924 | 446 | 414 |
| G | 1740 | 861 | 1434 | 1496 | 1446 | 394 | 378 | 1880 | 250 | 260 | 190 | 240 | 270 | 280 | 68.0 | 833 | 371 | 262 | 202 | 81 | 956 | 473 | 422 |
| H | 1538 | 805 | 1263 | 1325 | 1258 | 400 | 358 | — | 240 | 250 | 200 | 230 | 250 | 280 | 54.0 | 690 | 305 | 219 | 176 | 81 | 822 | 401 | 354 |
| I | 1680 | 851 | 1390 | 1465 | 1398 | 410 | 377 | 1780 | 240 | 250 | 180 | 240 | 270 | 270 | 61.0 | 750 | 329 | 245 | 189 | 76 | 925 | 435 | 427 |
| J | 1623 | 799 | 1351 | 1400 | 1342 | 408 | 369 | 1809 | 250 | 260 | 180 | 210 | 240 | 280 | 56.6 | 768 | 332 | 244 | 182 | 61 | 985 | 533 | 398 |
| K | 1664 | 864 | 1380 | 1451 | 1378 | 402 | 364 | 1765 | 250 | 270 | 190 | 190 | 260 | 280 | 61.0 | 750 | 329 | 244 | 195 | 81 | 900 | 455 | 382 |
| L | 1668 | 815 | 1381 | 1450 | 1381 | 406 | 364 | 1825 | 240 | 250 | 170 | 210 | 260 | 290 | 55.0 | 801 | 348 | 263 | 201 | 87 | 931 | 454 | 417 |
| M | 1604 | 815 | 1324 | 1379 | 1355 | 408 | 351 | 1726 | 240 | 270 | 180 | 250 | 270 | 290 | — | 743 | 323 | 238 | 190 | 83 | 903 | 457 | 389 |
| N | 1588 | 822 | 1308 | 1370 | 1313 | 378 | 352 | 1685 | 220 | 250 | 150 | 200 | 250 | 280 | — | 722 | 312 | 230 | 180 | 78 | 826 | 394 | 378 |
| O | 1724 | 827 | 1440 | 1490 | 1453 | 405 | 368 | 1861 | 240 | 250 | 180 | 240 | 250 | 300 | — | 819 | 349 | 278 | 192 | 87 | 941 | 436 | 453 |
| P | 1664 | 786 | 1374 | 1450 | 1393 | 385 | 342 | 1700 | 260 | 280 | 210 | 240 | 270 | 300 | — | 783 | 313 | 299 | 182 | 81 | 900 | 430 | 403 |
| Q | 1594 | 803 | 1334 | 1402 | 1305 | 450 | 375 | 1706 | 295 | 280 | — | — | 250 | — | 84.7 | 732 | 312 | 237 | 190 | 89 | 821 | 380 | 379 |
| R | 1650 | 835 | 1379 | 1465 | 1394 | 418 | 380 | — | 220 | 280 | 180 | 200 | 250 | 280 | 62.0 | 753 | 314 | 258 | 172 | 83 | 903 | 442 | 406 |
| S | 1629 | 812 | 1360 | 1429 | 1352 | 355 | 341 | 1774 | 230 | 250 | 190 | 240 | 245 | 280 | 55.0 | 775 | 347 | 258 | 192 | 75 | 923 | 461 | 408 |
| T | 1631 | 867 | 1373 | 1440 | 1352 | 410 | 368 | 1725 | 270 | 290 | 230 | 220 | 290 | 300 | — | 754 | 320 | 267 | 186 | 85 | 885 | 443 | 377 |
| Mean [ ♂ ] | **1661.6** | **827.4** | **1369.7** | **1441.1** | **1374.5** | **404.8** | **360.4** | **1782.0** | **249** | **263** | **186** | **224** | **258** | **277** | **60.1** | **762.3** | **329.9** | **257.9** | **187.5** | **79.4** | **901.8** | **438.0** | **404.4** |
| AA | 1564 | 761 | 1314 | 1358 | 1285 | 430 | 352 | — | — | — | — | — | — | — | — | 692 | 252 | 261 | 160 | 71 | — | — | 389 |
| BB | 1514 | 755 | 1247 | 1309 | 1258 | 330 | 311 | 1576 | 200 | 210 | 145 | 200 | 230 | 260 | 38.4 | 688 | 308 | 202 | 168 | 67 | 799 | 380 | 367 |
| CC | 1604 | 774 | 1337 | 1378 | 1317 | 419 | 357 | 1692 | 260 | 240 | — | 250 | 270 | 310 | 70.0 | 736 | 331 | 240 | 176 | 77 | 886 | 457 | 373 |
| DD | 1592 | 747 | 1318 | 1382 | 1340 | 344 | 325 | 1681 | 220 | 220 | 170 | 220 | 250 | 280 | 38.4 | 750 | 340 | 232 | 178 | 69 | 873 | 317 | 402 |
| EE | 1617 | 760 | 1343 | 1414 | 1375 | 335 | 316 | 1777 | 230 | 250 | 150 | 210 | 250 | 290 | 50.2 | 749 | 345 | 225 | 176 | 65 | 912 | 483 | 378 |
| FF | 1537 | 781 | 1270 | 1353 | 1282 | 365 | 340 | 1619 | 240 | 250 | 150 | 230 | 260 | 290 | 46.0 | 703 | 320 | 235 | 167 | 71 | 814 | 404 | 342 |
| GG | 1505 | 739 | 1248 | 1295 | 1256 | 426 | 356 | — | 270 | 250 | — | — | — | 310 | 68.0 | 676 | 286 | 232 | 166 | 73 | 816 | 367 | 384 |
| HH | 1647 | 797 | 1363 | 1440 | 1375 | 355 | 336 | 1760 | 220 | 230 | 160 | 240 | 260 | 290 | 52.0 | 786 | 354 | 243 | 182 | 73 | 921 | 437 | 426 |
| II | 1517 | 780 | 1253 | 1320 | 1306 | 342 | 315 | 1655 | 220 | 220 | 140 | 200 | 220 | 250 | 34.3 | 704 | 326 | 223 | 163 | 67 | 815 | 401 | 361 |
| JJ | 1546 | 761 | 1277 | 1342 | 1314 | 358 | 331 | 1645 | 230 | 240 | 150 | 250 | 270 | 290 | — | 709 | 298 | 230 | 183 | 76 | 850 | 417 | 373 |
| KK | 1597 | 754 | 1302 | 1368 | 1334 | 343 | 326 | 1583 | 240 | 230 | 200 | 250 | 280 | 290 | — | 720 | 311 | 241 | 175 | 65 | 907 | 454 | 395 |
| LL | 1490 | 712 | 1221 | 1249 | 1232 | 356 | 316 | 1600 | 240 | 250 | 240 | 260 | 270 | 280 | — | 723 | 297 | 256 | 167 | 73 | — | — | 349 |
| MM | 1501 | 713 | 1245 | 1319 | 1251 | 371 | 321 | 1550 | 230 | 220 | 200 | 260 | 280 | 300 | — | 697 | 299 | 228 | 163 | 73 | — | — | 393 |
| NN | 1585 | 720 | 1329 | 1385 | 1320 | 395 | 350 | 1725 | 250 | 250 | 160 | — | 290 | 300 | — | 747 | 310 | 241 | 194 | 79 | 878 | 409 | 409 |
| OO | 1593 | 740 | 1326 | 1370 | 1342 | 388 | 334 | 1702 | 230 | 250 | 180 | 230 | 270 | 300 | — | 752 | 322 | 232 | 187 | 73 | 893 | 439 | 405 |
| PP | 1537 | 784 | 1270 | 1324 | 1293 | 360 | 325 | 1646 | 220 | 240 | 160 | 250 | 270 | 290 | — | 730 | 313 | 187 | 178 | 76 | 842 | 397 | 394 |
| Mean [ ♀ ] | **1559.1** | **754.9** | **1291.4** | **1350.4** | **1305.0** | **369.8** | **332.0** | **1658.0** | **233** | **237** | **170** | **235** | **262** | **289** | **49.7** | **726.4** | **313.3** | **232.4** | **174.0** | **71.7** | **862.0** | **419.6** | **383.8** |
| *a* | 1671 | 810 | 1377 | 1449 | 1394 | 396 | 370 | 1790 | 250 | 250 | 170 | 210 | 230 | 280 | 61.0 | 792 | 356 | 253 | 181 | 78 | 946 | 403 | 426 |
| *b* | 1607 | 776 | 1329 | 1393 | 1329 | 366 | 333 | 1730 | 250 | 250 | 165 | 210 | 240 | 260 | 50.7 | 745 | 305 | 253 | 186 | 74 | 915 | 451 | 413 |
| *c* | 1516 | 740 | 1256 | 1307 | 1254 | 353 | 323 | 1630 | 220 | 220 | 180 | 200 | 240 | 250 | 44.0 | 699 | 285 | 242 | 189 | 68 | 839 | 415 | 371 |
| *d* | 1325 | 675 | 1078 | 1120 | 1077 | 300 | 296 | 1360 | 180 | 200 | 150 | 170 | 200 | 225 | 28.5 | 607 | 259 | 206 | 149 | 59 | 732 | 358 | 324 |

TABLE III B.

| | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 252 | 99 | 199 | 147 | 135 | 200 | 121 | 50 | 116 | 140 | 105 | 100 | 96 | 31 | 120 | 46 | 53 | 52 | 20 | 62 | 20 | 72 | 36 |
| B | 260 | 97 | 187 | 144 | 127 | 185 | 115 | 42 | 113 | 125 | 107 | 98 | 94 | 30 | 120 | 42 | 52 | 41 | 19 | 60 | 18 | 61 | 35 |
| C | 244 | 89 | 195 | 139 | 129 | 188 | 117 | 46 | 109 | 136 | 97 | 92 | 90 | 37 | 115 | 49 | 52 | 45 | 18 | 58 | 14 | 67 | 37 |
| D | 253 | 108 | 198 | 142 | 138 | 190 | 111 | 48 | 111 | 133 | 98 | 97 | 100 | 33 | 112 | 38 | 45 | 49 | 14 | 54 | 19 | 68 | 37 |
| E | 247 | 89 | 181 | 134 | 122 | 175 | 110 | 47 | 107 | 127 | 97 | 94 | 95 | 34 | 108 | 44 | 45 | 41 | 17 | 60 | 20 | 65 | 37 |
| F | 260 | 97 | 192 | 145 | — | ?200 | 127 | 50 | 113 | 146 | 105 | 96 | 97 | 40 | 116 | 46 | 52 | 49 | 20 | 66 | 15 | 65 | 35 |
| G | 270 | 95 | 195 | 139 | 132 | ?187 | 114 | 45 | 114 | 124 | 98 | 96 | 94 | 31 | 112 | 44 | 48 | 44 | 17 | 67 | 16 | 68 | 35 |
| H | 253 | 98 | 187 | 143 | 129 | 186 | 110 | 45 | 108 | 144 | 82 | 95 | 94 | 35 | 110 | 37 | 43 | 47 | 18 | 65 | 10 | 65 | 32 |
| I | 251 | 96 | 199 | 140 | 130 | 177 | 107 | 48 | 110 | 144 | 106 | 96 | 98 | 35 | 113 | 43 | 48 | 50 | 18 | 62 | 12 | 64 | 37 |
| J | 240 | 92 | 197 | 127 | 131 | 185 | 114 | 49 | 106 | 131 | 111 | 94 | 91 | 38 | 112 | 40 | 45 | 49 | 21 | 52 | 15 | 67 | 37 |
| K | 259 | 98 | 193 | 148 | 134 | 180 | 117 | 57 | 107 | 148 | 98 | 95 | 89 | 34 | 107 | 40 | 44 | 45 | 15 | 59 | 17 | 62 | 30 |
| L | 265 | 101 | 194 | 144 | 139 | 174 | 110 | 51 | 111 | 126 | 109 | 96 | 94 | 34 | 114 | 40 | 46 | 46 | 20 | 67 | 15 | 67 | 39 |
| M | 250 | 90 | 192 | 152 | 132 | 185 | 112 | 45 | 103 | 138 | 98 | 95 | 93 | 28 | 109 | 43 | 50 | 47 | 18 | 81 | 12 | 65 | 36 |
| N | 238 | 87 | 188 | 149 | — | 196 | 117 | 46 | 108 | 126 | 94 | 89 | 90 | 31 | 101 | 47 | 50 | 45 | 17 | 58 | 11 | 69 | 35 |
| O | 259 | 89 | 201 | 147 | 130 | 187 | 127 | 51 | 107 | 139 | 104 | 95 | 92 | 28 | 106 | 48 | 51 | 44 | 19 | 55 | 13 | 63 | 33 |
| P | 256 | 105 | 199 | 146 | 129 | 191 | 120 | 47 | 112 | 148 | 102 | 103 | 97 | 42 | 123 | 45 | 50 | 49 | 20 | 62 | 10 | 74 | 32 |
| Q | 257 | 110 | 203 | 146 | 133 | ?182 | 103 | 47 | 115 | 142 | 107 | 98 | 106 | 34 | 118 | 34 | 41 | 45 | 21 | 58 | 11 | 68 | 42 |
| R | 254 | 94 | 204 | 145 | 132 | 181 | 101 | 43 | 113 | 140 | 103 | 96 | 94 | 30 | 112 | 38 | 43 | 50 | 17 | 71 | 19 | 67 | 38 |
| S | 251 | 90 | 193 | 140 | 126 | ?200 | 125 | 56 | 95 | 140 | 114 | 95 | 94 | 35 | 109 | 46 | 50 | 50 | 18 | 65 | 20 | 76 | 40 |
| T | 246 | 106 | 199 | 142 | 133 | 187 | 115 | 47 | 105 | 140 | 110 | 95 | 97 | 40 | 107 | 47 | 54 | 52 | 22 | 70 | 11 | 73 | 41 |
| Mean [ ♂ ] | **253.3** | **96.5** | **194.8** | **142.9** | **131.2** | **184.8** | **114.7** | **48.0** | **109.2** | **136.9** | **99.3** | **95.8** | **94.7** | **34.0** | **112.2** | **42.9** | **48.1** | **46.5** | **18.5** | **62.6** | **14.9** | **67.3** | **36.2** |
| AA | 228 | 87 | 183 | 133 | 119 | 167 | 102 | 36 | 108 | 127 | 94 | 96 | 88 | 30 | 103 | 43 | 47 | 44 | 15 | 56 | 16 | 56 | 33 |
| BB | 225 | 84 | 173 | 133 | 124 | 171 | 102 | 42 | 107 | 121 | 90 | 87 | 89 | 29 | 97 | 37 | 43 | 40 | 15 | 51 | 18 | 57 | 33 |
| CC | 250 | 96 | 196 | 142 | 125 | — | — | — | 110 | 136 | 104 | 96 | 94 | 39 | 109 | 37 | 46 | 46 | 20 | 64 | 19 | 66 | 34 |
| DD | 233 | 90 | 184 | 133 | 126 | 163 | 104 | 40 | 105 | 122 | 102 | 92 | 87 | 35 | 111 | 44 | 49 | 37 | 17 | 62 | 15 | 58 | 31 |
| EE | 234 | 81 | 185 | 138 | 136 | 172 | 115 | 48 | 111 | 131 | 97 | 95 | 90 | 30 | 107 | 38 | 45 | 38 | 20 | 52 | 15 | 62 | 34 |
| FF | 235 | 90 | 187 | 138 | 132 | 168 | 103 | 44 | 115 | 131 | 97 | 95 | 90 | 35 | — | 37 | 41 | 43 | 19 | 59 | 21 | 61 | 30 |
| GG | 237 | 88 | 189 | 144 | 132 | 179 | 105 | 45 | 115 | 135 | 97 | 93 | 96 | 43 | 108 | 32 | 45 | 40 | 22 | 60 | 15 | 63 | 35 |
| HH | 245 | 92 | 179 | 139 | 135 | 152 | 100 | 40 | 102 | 130 | 107 | 91 | 97 | 29 | 111 | 35 | 40 | 38 | 11 | 59 | 21 | 57 | 31 |
| II | 221 | 81 | 174 | 137 | 133 | 150 | 101 | 42 | 105 | 121 | 86 | 89 | 85 | 29 | 103 | 37 | 43 | 36 | 17 | 52 | 21 | 58 | 31 |
| JJ | 236 | 87 | 175 | 146 | 129 | 157 | 105 | 41 | 110 | 132 | 93 | 95 | 96 | 28 | 110 | 44 | 50 | 40 | 17 | 55 | 10 | 62 | 30 |
| KK | 228 | 97 | 178 | 139 | 124 | 161 | 117 | 49 | 107 | 133 | 100 | 94 | 88 | 35 | 110 | 40 | 48 | 39 | 17 | 58 | 13 | 71 | 30 |
| LL | 235 | 92 | 181 | 135 | 123 | 170 | 101 | 36 | 106 | 127 | 96 | 90 | 90 | 38 | 101 | 42 | 45 | 45 | 19 | 54 | 20 | 68 | 34 |
| MM | 243 | 98 | 183 | 135 | 118 | 162 | 97 | 38 | 94 | 130 | 104 | 94 | 92 | 38 | 113 | 42 | 47 | 47 | 21 | 61 | 14 | 64 | 32 |
| NN | 264 | 94 | 198 | 145 | 132 | 163 | 109 | 36 | 107 | 132 | 91 | 97 | 89 | 29 | 110 | 44 | 48 | 42 | 19 | 54 | 8 | 60 | 32 |
| OO | 242 | 83 | 175 | 131 | 127 | 165 | 110 | 54 | 107 | 127 | 93 | 98 | 96 | 31 | 110 | 33 | 44 | 39 | 21 | 52 | 19 | 67 | 34 |
| PP | 240 | 88 | 182 | 144 | 126 | 158 | 107 | 44 | 106 | 129 | 94 | 86 | 91 | 29 | 105 | 38 | 44 | 40 | 19 | 52 | 17 | 64 | 33 |
| Mean [ ♀ ] | **237.3** | **89.3** | **182.6** | **138.3** | **131.8** | **163.9** | **105.2** | **42.3** | **107.2** | **133.2** | **96.6** | **93.0** | **91.1** | **33.0** | **108.0** | **38.9** | **45.3** | **40.9** | **18.1** | **56.3** | **16.4** | **62.1** | **32.3** |
| *a* | 254 | 96 | 191 | 141 | 134 | 175 | 113 | 44 | 106 | 135 | 95 | 98 | 94 | 30 | 107 | 41 | 47 | 47 | 15 | 56 | 15 | 65 | 34 |
| *b* | 256 | 97 | 188 | 132 | 139 | 172 | 108 | 40 | 105 | 122 | 95 | 89 | 87 | 29 | 106 | 39 | 45 | 39 | 16 | 50 | 24 | 65 | 37 |
| *c* | 239 | 87 | 190 | 130 | 131 | 170 | 104 | 49 | 105 | 124 | 89 | 90 | 97 | 30 | 102 | 37 | 43 | 43 | 17 | 50 | 19 | 67 | 35 |
| *d* | 209 | 87 | 174 | 127 | 131 | 163 | 87 | 37 | 101 | 115 | 85 | 81 | 86 | 28 | 90 | 31 | 34 | 37 | 11 | 49 | 18 | 55 | 34 |

TABLE IV.

| Index. | Reference. | Sex. | No. of Indivs. | Mean Value. | Sex. | No. of Indivs. | Mean Value. |
|---|---|---|---|---|---|---|---|
| Head Indices— | | | | | | | |
| Cephalic .... | 26, 1 | Male | 20 | 73·9 | Female | 16 | 75·8 |
| Height .. .... | 29, 2 | ,, | 18 | 67·3 | ,, | 16 | 70·0 |
| Breadth .... .... | 29, 3 | ,, | 18 | 92·3 | ,, | 16 | 92·3 |
| Facial .. .... | 29, 5 | ,, | 20 | 135·0 | ,, | 15 | 123·0 |
| Morphological Facial | 29, 6 | ,, | 20 | 83·8 | ,, | 15 | 79·0 |
| Mandibulo-Jugal | 30, 12 | ,, | 20 | 74·8 | ,, | 16 | 74·7 |
| Fronto-Jugal .. | 30, 13 | ,, | 20 | 80·1 | ,, | 16 | 83·6 |
| Nasal Elevation .... | 30, 16 | ,, | 20 | 39·4 | ,, | 16 | 44·2 |
| Nasal Breadth .... | 30, 17 | ,, | 20 | 93·2 | ,, | 16 | 90·5 |
| Ear .... .... .... | 30, 19 | ,, | 20 | 53·7 | ,, | 16 | 52·2 |
| Trunk and Limb Indices— | | | | | ,, | 16 | 52·2 |
| Brachial .... ... | 19, 1 | ,, | 20 | 78·3 | ,, | 16 | 75·3 |
| Forearm-Hand ... | 19, 2 | ,, | 20 | 72·8 | ,, | 16 | 74·4 |
| Hand .... .... | 19, 3 | ,, | 20 | 42·4 | ,, | 16 | 41·3 |
| Tibio-Femoral .. | 20, 4 | ,, | 20 | 92·7 | ,, | 13 | 93·6 |
| Limb .... .... | 20, 6 | ,, | 20 | 70·3 | ,, | 13 | 69·2 |
| Thoracic .... ... | 21, 18 | ,, | 19 | 142·0 | ,, | 13 | 142·0 |
| Cristo-Spinal ... | 20, 14 | ,, | 19 | 87·3 | ,, | 13 | 90·0 |
| Stature Indices— | 19, a | | | | | | |
| Sitting Height ... | | ,, | 20 | 50·0 | ,, | 16 | 49·0 |
| Arm and Forearm | | ,, | 20 | 35·4 | ,, | 16 | 35·1 |
| Thigh and Leg ... | | ,, | 20 | 48·4 | ,, | 13 | 51·4 |
| Biacromial .... .... | | ,, | 20 | 22·1 | ,, | 16 | 21·3 |
| Bicristal .... .... | | ,, | 20 | 15·5 | ,, | 14 | 16·8 |
| Manouvrier Proportional | | ,, | 20 | 96·0 | ,, | 16 | 106·0 |

ACKNOWLEDGMENTS.

I am indebted to Dr. T. D. Campbell and Mr. N. B. Tindale for their generous help in the preparation of this paper, and to Dr. J. H. Gray and members of the 1934 expedition for help and advice with the field work.

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DESCRIPTION OF PLATES II AND III.

PLATE I. Types of aborigines described in the text:—Males. 1. Pokkawinna (E); 2. Djitjibui (D); 3. Tintibanna (Q); 4. Ngaltjagintata (S).

PLATE II. Types of aborigines described in the text:—Females. 1. Thea *(c)*; 2. Ngalijuru (DD); 3. Kappina (GG); 4. Maggie (MM).

# NOTES ON THE NATIVES OF THE SOUTHERN PORTION OF YORKE PENINSULA, SOUTH AUSTRALIA.

BY *NORMAN B. TINDALE, B.SC.*

### Summary

The natives of southern Yorke Peninsula are represented today by a sole woman survivor, representing a family group which may have at one time numbered about sixty individuals. In the first part of this paper are recorded some fragmentary observations obtained from her. It is unfortunate that her knowledge is incomplete, and that the legends she related are , mere outlines of once treasured stories, only portions of which would be known to a woman.

# NOTES ON THE NATIVES OF THE SOUTHERN PORTION OF YORKE PENINSULA, SOUTH AUSTRALIA.

By Norman B. Tindale, B.Sc., Ethnologist, South Australian Museum.
(Contribution from the South Australian Museum.)

(Read April 9th, 1936.)

The natives of southern Yorke Peninsula are represented today by a sole woman survivor, representing a family group which may have at one time numbered about sixty individuals. In the first part of this paper are recorded some fragmentary observations obtained from her. It is unfortunate that her knowledge is incomplete, and that the legends she related are mere outlines of once treasured stories, only portions of which would be known to a woman.

The second part of this paper consists of a vocabulary and list of place names. The majority of the 410 words and place names in it were gathered by Mr. J. Howard Johnson during the years 1898 to 1900; principally from the same woman survivor of the aborignes at Marion Bay and from her husband, who was of European extraction. Her people apparently belonged to a local group, called Warri or Worri [War:i] of the Narranga [Nar:anga] Tribe. The notes and vocabulary give a useful insight into the life of this tribe, which would have otherwise remained unchronicled, save for a few scattered references in the literature of the Australian aborigines.

In 1935 it was possible for the present writer to visit Marion Bay and to obtain the outlines of the stories, and to confirm the list of words with the same native informant (Louisa), now grown to a great age. It was possible to re-write the words in a phonetic system adopted at the University of Adelaide,[1] and to add some new details. Because of the dual sources of the original data it has been considered desirable to print the vocabularies in separate columns, as gathered by Johnson and by Tindale. The convention has been adopted of grouping words commencing with [b], [d] and [g] with the words [p], [t] and [k], respectively, for these pairs of sounds are often confused and little differentiated by the natives. The English description of the vocabularies is based on Johnson's work, but has been amplified and extended to include the new material gathered. In a few cases our informant has forgotten the words formerly related, and in such cases there is a blank in the first column.

Isolated words in the text which are spelled according to the above system are placed within square brackets.

The similarity of this Yorke Peninsula dialect with that spoken by the members of the Kaurna or Adelaide Tribe indicates a close relationship between the two peoples. Their boundaries adjoined near the head of St. Vincent Gulf. This relationship was recognised by Schmidt.[2] In his work both dialects are included under "Meyu Sprachen." The last survivor of the Adelaide Tribe, Ibaritja, with whom some work was done before her death in 1929, considered that the Narranga spoke her own language, but without clearness. Our aged Yorke Peninsula informant thought similarly of her eastern neighbour's speech; she had known Ibaritja and recognised

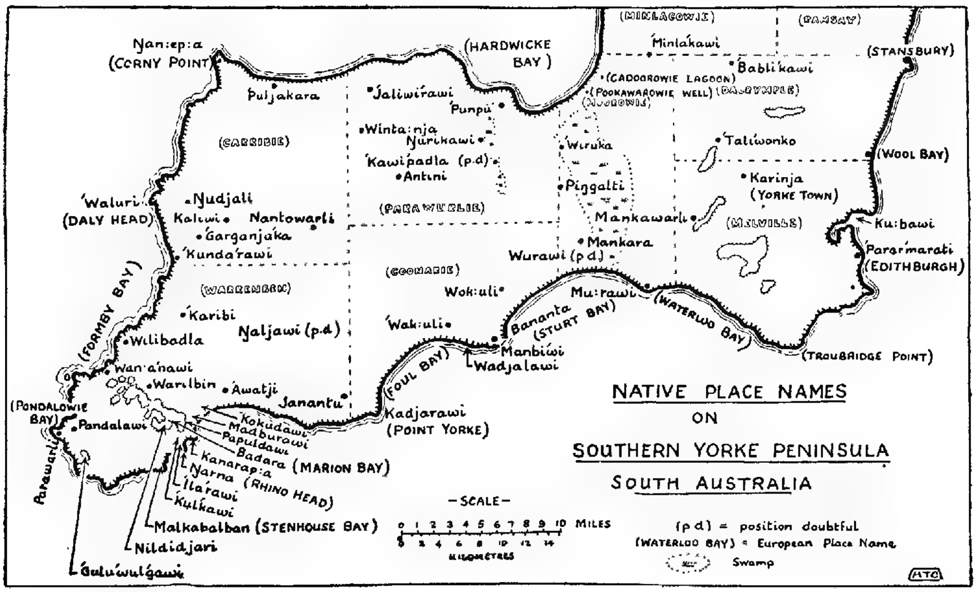
(1) Tindale, N. B., Records of the S. Aust. Museum, vol. v, 1935, p. 261-274.

(2) Schmidt, P. W., Die Gliederung der Australischen Sprachen. Wien, 1919.

that the dialects had much in common; nevertheless, she thought that Ibaritja "was hard to understand."

To assist comparison some Adelaide Tribe words are given in the appropriate places. These are spelled according to Teichelmann and Schürmann's [3] originals. The Kaurna origins of such additions are indicated by the letters KA. which precede them. Some Kaurna words terminating in [o] seem to be better rendered in southern Yorke Peninsula forms by [u].

When compared with Kaurna there seems to be a tendency for the initial [p] sounds to become [b], [k] to become [g], and [t] to become [d], but in the body of the word this does not often occur. The same tendency has been recently noticed in the words of the language of the people in the country near Laverton in Western Australia, when contrasted with the same words in the Pitjandjara dialect of the Mann Range in north-western South Australia.




I am indebted to Miss M. Klem, of Corny Point, for confirming localities, Mr. H. T. Condon for checking of the names of the birds, and to Mr. H. H. Finlayson for help in the identification of mammals.

Mr. J. Howard Johnson kindly gave permission for his manuscript vocabularies to be published in the present form. I was grateful for their use while working with Louisa.

## Notes and Legends.

The country of Louisa's mother and her kinsfolk was at the south-western extremity of Yorke Peninsula, and extended as far north as Daly Head. Their eastern boundary was at 'Bananta, which is slightly to the east of Nugent, on Sturt Bay. In this triangular area of some 200 square miles there lived the Warri ['War:i] group of the Narranga ['Nar:anga] Tribe, whose country extended northwards as far as the fringe of the South

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(3) Teichelmann, C. G., and Schürmann, C. W., Outlines of the Aboriginal Language . . . Spoken . . . around Adelaide. Adelaide, 1840.

Hummocks Range ['Nantu'waru], where the country was inhabited by people who spoke the ['Nantu'waru], literally "the kangaroo language," and belonged to another tribe.

There were many place names in her country besides those given in the accompanying list, but Louisa had forgotten them. She explained also that "My people never named the inland places, only those near the coast."

The places named were waterholes and soaks, as well as good hunting and camping places. At Daly Head, for example, the water was called ['Waluri]; it ran into the sea from under a big rock, at tide mark. There was a big rock there from which they fished for Snapper *(Pagrosomus auratus)*. At Marion Bay, Kokudawi ['Kokudawi], was the principal place for fishing. Most of the spearing was done at night; fish spears with a double head were used; torches were burned to attract the fish, these were made of bark. The best place to spear Butterfish *(Sciaena antarctica)* was at Penguin Point ['Kanarap:a]. In December many Yellow-tail *(Seriola grandis)* were caught at Kokudawi.

Fish nets were made from the fibre obtained from broad flags ['buntu, 'buntu]. These were placed in a long hole or oven and covered with hot ashes for about a day. After this preliminary wilting the stems were chewed and the fibre made into string by working and rolling on the thighs. Women chewed the fibre; it made their teeth smooth, and sometimes caused them to be sore. Each man owned his own net, which was six to eight feet long, five to six feet high, and usually of small mesh, suitable for fish such as the sea Mullet *(Mugil cephalus)*. Sometimes nets with a larger mesh were made for catching the Australian Salmon *(Arripis trutta)*. In fishing three or four nets might be joined together, with sticks standing between to support them. There were neither sinkers nor floats. The people dived down to secure the fish. Bundles of grass were sometimes tied on the top of the nets to keep the fish from jumping over, and might help to keep the nets floating. When many nets were joined together they would form a line many hundreds of feet long.

Nets for snaring wallabies were made from kangaroo and wallaby sinews. These were placed on the kangaroo pads after fences of brushwood had been built and apertures left at intervals to guide the animals to the nets. At these apertures a triangular bag net of sinews ['minti] was tied. It had a string looped around the opening. When the animal entered the bag it thrust its head down into the small pocket end. The noose string, which was tied to a branch, closed the mouth of the bag.

The natives made net bags knotted like the fish nets, called ['mandeiko]. They carried these over their shoulders, supported by a string.

Coiled baskets were unknown to the natives of Marion Bay. After the white men came a native woman visited them, either from the Murray River or the Coorong, and taught some of the women how to make them.

At Pondalowie [Pandalawi] there was a famous kangaroo hunting place, where the animals were driven on to a small peninsula and slaughtered. Plain wooden spears were used in hunting. Kangaroo and wallaby skin rugs were made from the pelts of these animals and worn as cloaks. There is an excellent example, made from Dama wallaby skins, in the South Australian Museum (A. 6,409), which was presented by Mr. J. Howard Johnson. It bears on its inner surface a regular pattern of crossed lines formed by rubbing the folded skin with a broken piece of quartzite hammerstone. Though of comparatively recent manufacture, this rug was made by an aborigine in the native way. The skins were simply pegged out and dried in the sun, and, after trimming to a regular shape, they were stitched together with kangaroo

or wallaby tail tendons. The cross markings were made by folding and firmly pressing the skins, fur side inwards, and then by scoring the prominent edges of the folds thus formed with the sharp edge of a stone implement or shell. In this case the markings were simply to make the skins more flexible, but besides such geometrical patterns it was the custom to mark the skins used for rug making with various other, and more irregular, designs, which may have been signs of proprietorship. Such figures were often made more conspicuous by colouring them with red ochre or other native pigments.

When worn as a cloak the rug was passed under the right arm and fastened over the left shoulder with a wooden or bone pin. Both arms were thus left free.

The gum ['budala] of the wattle trees ['kundaraka] was sweet and liked as a food. There were many trees with this gum near Moonta.

Wild peaches ['parabara] were much liked. Louisa remembered an old song which came from the north country, and which was sung at Marion Bay. It tells how the sun "burned" or "made red" the peaches.

SONG OF THE PEACH TREE.

| | | | | |
|---|---|---|---|---|
| [Parabara | 'wanarni | 'tjindu | 'kalala | 'kambarni |
| wild peaches | "come" | sun | light | burn |
| *(Eucarya acuminata)* | | | | |
| 'jarugareitja | 'madeitja | 'tjindu | 'kalala | 'kambarni.] |
| "go round and gather them" | | sun | light | burn. |

"Wild peaches hanging in the trees, the sun will burn you (to the colour of fire) we will gather you (for food)."

Louisa's mother was born at Marion Bay; her husband was known as "King Tommy." His country extended as far north as Wallaroo; he came often to Marion Bay. He had a very loud voice, and one could hear him talking "half a mile away." "We married our own people. We did not have anything to do with strangers. We married with people only as far north as Wallaroo. If we obtained a woman from the 'North people' (the Kangaroo people north of the Hummocks Range) they would come and take her back again."

At ['Papuldawi] (Bubladowie WH, Section 11B) large numbers of people congregated for ceremonies. The adult menfolk initiated their young men there. At such times natives from the northern end of the Peninsula came to Papuldawi.

The bodies of natives were stated to be sometimes buried in the ground. At other times they were smoke-dried over a fire, tied up in grass and sheets of bark in a flexed condition and placed in caves, such as occur near Corney Point [ŋan:ep:a].

THE STORY OF NGARNA AND 'BADARA.

Ngarna [ŋarna] was a big, powerful man, who lived on Yorke Peninsula. He was a powerful club thrower. On one occasion he stood on the point of Wardang Island ['Wordaŋ], and saw a woman seated on the rocks at Point Turton [Punpu]. She was fishing, and had a baby tied to her back. He hurled his club [wir:i] across miles of water and struck the woman dead.[4] He exerted such effort that he imprinted his foot-track on the rock. The woman turned into a large stone (apparently a large granitic erratic) at Punpu. Near to it is another rock with a pattern on it like the rectangular

(4) According to Louisa's son, who has lived at Point Pearce, the club was thrown from near Port Victoria to Point Pearce, i.e., from 'Gagat'hi to "Boys" Point.

pattern to be seen on wallaby skin cloaks; this is the woman's cloak ['palta] or rug. Ngarna desired to kill Madjitju (literally, the bat man), who was a small person, one of the ['ilara] people. He walked down the Peninsula to ['Warilben] (Section 20, Warrenben), accompanied by a party of men. They planned to vanquish the bat man, who proved to be too clever for them. He turned Ngarna into a sleepy lizard and then escaped by turning himself into a bat and flying away. Ngarna met a man called Badara at Emu Bay (between Rhino Head and Penguin Point). Badara was a little man and was lying down at rest on the flat near Ilarawi (Hillderowie Well, Section 2, Warrenben). Badara made some remark, whereupon the big man Ngarna came up and tormented him, saying, "You are only a little fellow; what you say is a joke." Before the little man could rise, Ngarna attacked him. A fight commenced. Badara was struck down by a blow from Ngarna's large club ['ŋal:a'wiri]. Ngarno thereupon cut him open, dragged out his intestines, and tore out the caul fat [man:i]. A clearing in the mallee scrub marked the place, and a bare patch of ground remained where Badara's intestines were thrown out on the grass.(5) Ngarna then picked up the body of his enemy, carried it into the Salt Lagoon (Section 10, Hundred of Warrenben), and threw it down in the middle of the lake. A pile of stones remains there to mark the body of Badara; they are Badara's bones. There were no stones there before Badara was killed. Sea-gulls nest on Badara nowadays, and one may go out, in summer, and gather the eggs. Ngarna travelled around the coast. At Nildidjari ['Nildi'djari], near Cape Spencer (6) he made a rug of wallaby fur sewn with sinews, and left it near the beach. It remains as a large rock; there are seams on it like the scarified marks on a rug. Finally he himself turned to stone at Rhino Head, and became the large outlying rock on the point. His wife sat down at his feet, and is represented there today as a large block of rock at the base of the cliff. According to a version obtained by Mr. J. Howard Johnson, Ngarna (called Arrner) was a giant, supposed by the natives to be buried at Royston Head, near Cape Spencer. He was a big man who quarrelled continually with another giant called Badara (Budderer). Finally Ngarna threw a club from Point Turton which killed Badara, who was near Minlaton. Johnson's story came from Louisa's husband.

Madjitju was a clever man; he was a man, not a bat. He stood on the shore of the sea at a place near Marion Bay. He made a shark ['widat:a] and placed it in the water; it commenced to wag its tail and swam away. At this Madjitju was surprised and shouted out after the animal:

["Wan:i 'adjini 'nargun."]
"Let me look I want to see."

He wished the shark to "turn around, hold your head up, let me have a look." The shark did this to please Madjitju, and continues the practice today. The *madjitju* afterwards became a bat. Before turning into a bat he made all the natives of the country.

Sutton (7) mentions this being under the name *majaja* in his brief account of a somewhat different story.

At Pandalawi (north-west corner of Section 26A, Hundred of Warrenben) there lived a wicked old woman named 'Bulgawan. She was out fishing, lying on the rocks, when she became turned into stone; she lies

(5) This place has been recently ploughed and cultivated.

(6) According to Miss Klem this place is at the lagoon near Cape Spencer, worked for gypsum. (Sect. 18,500, etc., Hundred of Warrenben.)

(7) Sutton, T. M., The Adjahdurah Tribe of Aborigines on Yorke Peninsula. Proceedings of Geographical Society of Australia, South Australian Branch, 1889, p. 4.

there still. The sea water rushes into a long tunnel under the rock and comes out in a fountain near the shore, throwing up a column of spray. The natives considered that the water entered by her mouth and was ejected from her anus.

At ['Ila'rawi] there once lived many ['ilara]. They were little people. They could not talk. They had mud camps, and according to Louisa you may still see the traces of their huts as mud heaps in the scrub. They were like any other natives, only small ("3 feet"). They could not talk the Narranga language, and only made "strange noises." They came to water at "Emu Waterhole," and so the place is called Ilarawi.

Mr. Tom Egginton, who was born in the district, and lives at Warooka, speaks the native language, and was able to add the following details to the above notes and legends:—

Ngarna was a strong man. He threw a club from Wardang Island to Point Turton and killed a woman. He was outwitted by Madjitju, whom he tried to kill. Ngarna was turned into a sleepy lizard and remains as one today.

Bulgawan was once a woman who is now a "blowhole" at Pondalowie Bay. Air, froth, and water are forced under the rocks and is ejected as a fountain from a round hole about a foot in diameter.

### The Evil Spirit called Wainjira.

One day an old man went digging out kangaroo rats at Point Yorke, called Kadjarawi (Section 97, Hundred of Coonarie). He had two spears with him because he had the notion that an evil spirit being called ['Wainjira] might be lurking about in the scrub. He was busily engaged in his task when he felt or heard a big wind approaching. He knew that this was Wainjira's doing. "Ah! I can hear Wainjira coming." He hid himself behind a clump of mallee, where there was a narrow space ['talbu], between adjacent clumps. As Wainjira passed between the trees, he tripped him up by passing one spear between his legs, and pierced him with the other. It took a large crowd of men to carry Wainjira away to the beach at Kadjarawi, and there to throw him into the sea. Great waves sprang up and rushed over the rocks as the giant fell into the water, and they continue to do so today. Wainjira was a ['Nukunu], i.e., a northern stranger, and was supposed to be tall in stature.

The ['Ilara] were a group of small people who lived in the scrub near Marion Bay. They were stupid people and could not speak to others. They lived in mud huts in the scrub.

## GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'aipam: a | I am coming | i-bumma |
| 'alalatu | native cranberry *(Astroloma humifusum)* | al-lal-a-doo |
| 'alibuma | you and I are going; I am going (with you) | ally-bumma |
| *am: i | breast, mother | um-me |
| aŋki | female, girl, young woman | arn-kee, ung-kee |
| 'antubatu-'wite'katja | "mouse" (a short-armed animal; digs quickly); *cf.*, KA., witte, quick; katta, digging stick | untoo-buttoo-vith-e-catcha |
| apul: u | that other one; what is his name? | ubble-loo |
| 'arntu | arm | arrn-too |
| 'atjika | a mate, my mate | ud-jig-ga, ud-ge-ga |

*In the absence of Mr. N. B. Tindale abroad, these proofs were kindly read by Professor J. S. Fitzherbert, of the Adelaide University. Professor Fitzherbert is of the opinion that there should be an accent mark before each word in the first column of the vocabulary. The letters KA. indicate Kaurna, or Adelaide tribe, as set out in the context.

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'awatji | estuary catfish *(Cnidoglanis megastoma)* | ower-jee |
| 'ilara | A dwarf people who were supposed to live in former times at Ilarawi. They made camps of mud, traces of which, as mounds, are supposed to be present in the scrub country. | |
| 'indala | fairy penguin *(Eudyptula undina)* | yin-da-la |
| itja | skin | |
| itjina balta | boot (new term) | |
| 'ga:ro | blood | gurroo |
| 'kainbara, **nudli** | butterfish or mulloway *(Sciaena antarctica)* | gyne-burra |
| 'kaipulja, 'gaibulja | pardalote *(Pardalotus)* and allied species of birds | gy-bull-ya |
| 'kaijera | swamp | ki-er-a-wurta |
| kaijera | tea tree, black *(Melaleuca pubescens)* | ki-er-rah |
| gaka-nak:olitji | headache (*lit.*, head spinning around); *cf.*, K A., kakka, head, nakkondi, awake, ti, prohibitive mood | gocker nargo-lidge |
| 'gakanu | hat | gurg-gun-noo<br>gurr-gun-noo |
| 'gaka-puljoli | black-naped snake *(Denisonia gouldi)*; *lit.*, black head; *cf.*, K A., kakka puljonna, head black | cooka-bull-yooly |
| 'gakabun:u | hat | |
| 'gakati | shoulder-blade; *cf.*, K A., kartakka, shoulder | gug-gut-tee |
| 'gaka-warli | hat; *cf.*, K A., wodli, house | gucka-wurley |
| 'gaka-wilja | hair on head; *cf.*, K A., wilya, foliage | gugga-willyer<br>cucka-willya |
| 'kak:a, 'gak:a | head | gock-a, guck-ker |
| 'gak:a 'bin:ani | flat forehead | bucka binyinny |
| 'kaka 'tilali | red-headed person | |
| 'kalala | to light up (*e.g.*, a fire) | |
| 'kalalu | thornbill *(Acanthiza)* | gul-ul-loo |
| 'kaltitja | to be enamoured (with any object) | gul-didger |
| 'kaljaru | wallaby *(Thylogale eugenii)* | culyeroo |
| 'kam:idla | mother's mother (woman speaking) | |
| kambarni | to burn scrub or Dama, to ripen in the sun | |
| 'kanara | north | cun-arra |
| 'kanika | to bark (like a dog) | gon-nick-ker, or<br>can-nick-ker |
| 'kani'gar:a | cockroach | gunning-gurra |
| 'kanti | thigh; *cf.*, K A., kanti, thigh, leg | cun-tee |
| 'kanti palta | trousers (new term) | cundybulta |
| 'kanduwaru | a species of wading bird | |
| 'kanu-barti | scorpion, *cf.*, K A., karndoworti, species of scorpion; kuinyo barti, death grub | gunnee-wurta, or<br>gunner-berty |
| 'gapatja | ankle | gub-ut-cha |
| 'kabi, 'kawi, 'gabi | water; *cf.*, K A., kauwe, water | cabby, cow-wee, cowie |
| 'gari, 'kari | emu *(Dromaius novaehollandiae)*; *cf.*, K A., kari | gorry |
| 'gari 'wop:a | fly whisk (*i.e.*, tuft of emu feathers); *cf.*, K A., gariwoppa, tuft of emu feathers | gurry-woo-poo |
| karkala | "pigface" *(Mesembrianthemum aequilaterale)*; *cf.*, K A., karkalla, a species of plant, the fruit of which is eaten | gurrdguller |
| 'garkanja, 'karkanja | Nankeen kestrel *(Falco cenchroides)*; *cf.*, K A., karkanya, a species of hawk | gurr-gunya |
| karlko | shea-oak *(Casuarina Muelleriana)*; *cf.*, K A., karko, she-oak | curl-koo, currlk-oo |
| 'garntu | thunder and lightning, *cf.*, K A., karndo, thunder or lightning. | currn-too |
| 'karto | wife | |
| 'garuga'larto | wood-swallow *(Artamus)* | gurr-goo-larrt-too |
| gatankala, **kuŋgula** | blue swimming crab *(Portunus pelagicus)* | gud-ung-ala |
| 'gatapit'parti | groper *(Achoerodus gouldi)* | gutter-be-berty |
| 'kadla | fire, any light; *cf.*, K A., gadla, fire | currd-la |
| 'kadli | dingo, wild dog *(Canis familiaris dingo)*; *cf.*, K A., kadli, dog | cud-lee |

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'kadbari, 'gadburi | snapper *(Pagrosomus auratus)* | cud-burry |
| 'gad : ara | stingaree *(Urolophus testaceus)*, small species | gud-der-ah |
| | fiddler, a species of ray | guddoo-la |
| 'gat : ika | female of red kangaroo *(Macropus rufus)* | guddi-ga |
| 'katurta | sword stick, a fighting club | guthurta |
| 'gawana | mother's brother | |
| 'kua, 'kuwa | crow *(Corvus)*; *cf.*, K A., kua, crow. | goo-we |
| kua-mil : atu | a real thief; *i.e.*, one who takes by force, like a crow; *cf.*, K A., kua + milla, violence, taken by force | goowa millado |
| gulalja | Australian salmon *(Arripis trutta)* | gool-ul-ya |
| 'kuladi | gray butcher-bird *(Cracticus torquatus)* | goo-laddie |
| 'kulu | barley grass *(Hordeum maritimum)* | coo-loo |
| 'kunara | north, north wind | |
| 'kundaraka | A species of wattle which yields an edible gum called budala, which see | |
| 'guŋanja, kuŋanja | baby, a small child | gung-un-yer |
| kuŋanja-nantiku | woman (with child in arms); *lit.*, child owner | oong-unya narndickoo |
| kuŋgula, gatankala | blue swimming crab *(Portunus pelagicus)* | |
| 'kuninti | mosquito | |
| 'kunkaratji | birth | goon-gurrage |
| 'kunda | wallaby *(Petrogale* sp., probably *P. xanthopus)* Only found in rock country; was never found on southern coast of Yorke Peninsula. | coon-ter |
| 'gunti'mar | chestnut teal *(Querquedula castanea)* | goon-de-mar |
| 'guntu | chest; *cf.*, K A., kunda, chest | coorn-too |
| 'kunjulu parni | swearing; an oath | goonyer-a-barnin |
| 'kupil : a | grog; *cf.*, K A., kopurla, seawater, intoxicating drinks | goo-billa |
| 'gup : a | "devil" or "spirit being" of an ordinary kind | goo-binya, coop-a |
| 'kura, 'gura | broad daylight; *cf.*, K A., kuranna, noon | goora |
| 'guralu, kuralo | daytime | gooraloo |
| 'kuran : a | good | goo-ranner |
| 'kuran : a-mulki | good looking (good looking person or face) | goo-ranner-moolkee |
| 'guratu, 'kuratu | banded-carpet shark *(Orectolobus devisi)* | goorat-too |
| 'guriweidj | singing (a corroboree) | coordy-witch |
| 'kur :'ti | native peach *(Eurcarya acuminata)* | goorb-tee |
| 'kudaka | young of kangaroo; *cf.*, K A., kurtakka, young kangaroo | gooduck-a, gudaga |
| kudaka-palta | rug made from kangaroo skins | gudaga-bulter |
| 'gudil'jaro | lark | |
| gudlu | louse | |
| gudlu, kudlu | louse *(Pediculus)* | cood-loo |
| 'kutju | one; *cf.*, K A., kutyo, little, few | goot-choo |
| 'kuja | fish (any kind of), applied sometimes to butterfish; *cf.*, K A., kuya | gooya, coo-ya |
| 'ku : pa | southern spiny lobster *(Jasus lalandi)*; *lit.*, ugly looking; *cf.*, K A., kunggurla, crawfish | coop-a |
| 'kuwa | crow *(Corvus)* | goo-wa |
| 'mai, 'maji | bread, vegetable food; *cf.*, K A., mai, vegetable food | mi-e, or mi-yee |
| 'maiabaro | Cape Barren goose *(Cereopsis novae-hollandiae)*; anything eatable, mai = bread, barro = meat | mi-e-burro |
| 'makakilakila | skink lizard *(Leiolepisma)* | mug-a-gilla-gilla |
| 'mak : o | clouds; *cf.*, K A., makko, cloud | muck-koo |
| 'makuwarta | heel | mug-wurta |
| 'malawari | sandfly *(Culicoides)* | mulla-wurry |
| 'maldalja | foreign speech (German, gibberish, unable to understand); *cf.*, K A., maltangaitya, speaking badly | mul-dulya |
| 'maldeira | pink-flowered teatree *(Melaleuca acuminata)*; *cf.*, K A., maltarra, a species of eucalyptus resembling the stringy bark tree | mul-der ra, or mul-deer-ra |

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'malka | white; a limestone waterhole | mulka |
| 'mambala | anyhow | mum-bala |
| 'mana'tjena | tremendous, big; *i.e.,* big kangaroo, man (anything). | munna-gin-er |
| 'manka | Australian goshawk *(Astur fasciatus)* | mun-ka |
| 'maŋka | "black and blue ant"; apterous female of a thynnid wasp *(Diamma bicolor).* | mun-ker |
| 'mankawi, 'marnkawi | three (no higher numerals known); *cf.,* K A., marnkutye, three | mung-ga-wee |
| 'maŋku | cross or angry | mung-goo |
| 'man: i, marni | fat, caul fat | murrn-nee |
| 'manpi | common bronzewing *(Phaps chalcoptera);* sometimes applied to other pigeons | mun-pee |
| 'mandeiko | swag; *i.e.,* parcel wrapped with string; net-bag made of *puntu* fibre carried over shoulder with string; *cf.,* K A., mandarra, string | mun-duck-koo |
| 'manti | sound of a blow | mun-tee |
| 'mandiltu | stingray (a large species of) | mun-dilt-too |
| 'mandipalta | stingray *(Dasyatis brevicaudatus)* | mundy-bulter |
| 'manto | boy; *cf.,* K A., yerli, male | yurd-lee |
| 'mantu | fighting-man, an adult | mun-too |
| 'manja | rain; *cf.,* K A., manya, cold, rainy | mun-ya |
| 'marna | big (fat) | murrn-na |
| 'marni | fat; *cf.,* K A., marnendi, to be fat | murrn-nee |
| mar: a | hand (includes wrist and fingers); *cf.,* K A., marra, finger, hand | murra |
| mar: a piri | finger nail; *cf.,* K A., marra birri, nail of the finger | murra-birry |
| 'mar: a-walpa, 'wititu | native cherry *(Exocarpus cupressiformis)* | murra-wulpa, whid-dit-too |
| 'mar: awitji | *lit.,* "many hands," octopus; *cf.,* K A., marra, hand; witte, much | murra-widgee |
| 'mardi kawi, 'mardi 'gawi | mirage | murr-da-gowie |
| 'madle | inside of thigh; *cf.,* K A., madleari, the gluteus muscle. | mud-dlee |
| 'matjara | moderately strong waves | mud-ger-ra |
| 'Madjitju | Name of a supernatural being who takes form of a bat; the name is also applied to bats in general; *cf.,* K A., maityo maityo, bat. | mud-jet-choo |
| 'madjitju | bat; *cf.,* K A., maityo maityo, bat | mud-jet-choo |
| 'mat: a | knee; *cf.,* K A., matta, knee | mut-ta |
| 'mena, mina | eye; *cf.,* K A., mena, eye | min-na |
| 'mena 'guguli | cross-eyed | |
| mena-puti | eyebrows; *cf.,* K A., mena + puti, eyes + hairy | minna-booty |
| 'minka | bad; *cf.,* K A., mingka, wound, hole in garment | mink-ka |
| 'miŋka | long-needled wattle *(Acacia longifolia)* | ming-ka, more-ra |
| 'minkara | silver wattle *(Acacia rhetinodes)* | ming-gurra |
| minti | triangular net bag made of sinews, used in snaring wallabies | |
| 'minja | a white-flowered bush, a species which grows on beach | minya, or meen-ya |
| 'Mitji | a name | Mit-chee |
| 'mok: a | egg, *cf.,* K A., muka, egg | mooka, mook-ker |
| 'mora | small-needled wattle *(Acacia rupicola)* | more-ra, morea |
| 'mukalta | kidney; *cf.,* K A., muka, egg; anything of a circular or oval shape | moo-gul-ta |
| 'mula-'kudaka | starved young kangaroo | moola-good-da-ga |
| 'mulara | boobook owl *(Ninox boobook)* | mool-e-ra |
| 'mular: a | pregnant; with young | moo-ler-ra |
| 'mulawi | cormorant *(Phalacorcorax* sp.) | mool-a-win |
| 'mulki | face | mook-ke |
| 'mulka-pinjini | flat face | moolka binyinny |
| 'muŋka | thick-tailed gecko *(Gymnodactylus miliusi)* | moonk-ker |

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'mun:i | stinging ant, a fierce species of | |
| 'mun:u | white winged chough *(Corcorax melanorhamphus)* | moon-noo |
| 'mura'warti | sleeping lizard *(Trachysaurus rugosus)* | moo-rower-tee |
| 'muru | white-backed magpie *(Gymnorhina hypoleuca)* | moor-roo |
| 'murugadja | crying; *cf.*, K A., murka, cry, weeping | moor-gudge |
| 'mudatj | tadpole | mood-dach, nood-dach |
| 'mudla | nose; *cf.*, K A., mudla, nose | mood-la |
| 'mudlanki | old woman | mood-lunkie |
| mudlabaki | miserable (out of sorts) | moola bucky |
| 'mudlabaki'napika | cold south wind; *lit.*, "a nose freezer" | moola bucker nubber nigger |
| 'mudla wikili | long-nosed; *cf.*, K A., mudla, nose; wikendi, to find fault with | mudla wigilly |
| 'mutja | stump | |
| 'muja | seaweed | moo-yer |
| 'nagura | whale | wol-burra, wul-burra |
| 'nagura-wadli | blow-hole (*lit.*, whale's nest); orifice in limestone cliff whence wave action forces a stream of water or vapour | wulburra wordly |
| nanto, nantu | kangaroo, old male grey *(Macropus giganteus);* var., *melanops; cf.*, K A., nanto, male kangaroo | nanto |
| nanto | horse (originally pindi nanto; *lit.*, white man's kangaroo); *cf.*, K A., pindi nanto, horse | nan-toe |
| 'nanto-mak:i | horse-shoe | nanto-muckee |
| 'nanja | pubic hair | nun-ya |
| narni | tawny frogmouth *(Podargus strigoides)* | narrn-ne |
| 'ŋal:awiri | long waddy; *cf.*, K A., ngalla-wirri, a long, heavy club resembling in form a sword | nulla-whirry |
| 'ŋam:i | mother | |
| 'ŋarata | back | now-er-ta |
| 'ŋarna | A powerful being who possessed great skill at club throwing; he threw a wir:a from 'Wordaŋ and killed a woman and child who were fishing at Punpu (Pt. Turton). He sought a quarrel with a small man called Badara, killed him with a 'ŋal:awiri club, removed his caul fat (man:i), and threw him into a salt lagoon. Ngarna became turned to stone at Rhino Head. | Arrner |
| ŋar:i | teal (any duck) | nurry |
| ŋaru | yoke of egg | nurr-roo |
| 'ŋarula | centipede | nulloo-ra |
| 'ŋatju | my or mine; *e.g.*, 'natju-'kadli, my dog | nally-go |
| 'ŋatju mulki | my face | |
| 'ŋadjali | pipeclay | |
| 'nini-ŋanki | you are a woman; *cf.*, K A., nganki, woman. | ninny-unkie |
| 'nib:ali | wrinkled | |
| 'nip:u | black man | nip-poo |
| 'nip-waŋki | black women | nip-wunkie |
| njiŋkali | "master," "your father" | nin-gully |
| 'nuk:e | cold in the nose (mucus of the nose) | nook-kee |
| 'nukunu | wild blackfellows from the north; phantom, ghost; the worst kind, always causing harm. The greatest evil was caused by a bald-headed nukunu, pirika-nukunu, who was greatly feared. | noog-gunner |
| 'nudli, **kainbara** | butterfish, mulloway *(Sciaena antarctica);* called *nudli* "because he has a bent tail" | noodly |
| ba! | look out (an exclamation); *e.g.*, when one sees a snake, one exclaims ba! | buh |

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'baitja | snake, any species, also applied to insects; *cf.*, K A., paitya, vermin, reptile | bu-cher, buy-cher, but-cher |
| 'baga'ku | crested bell-bird *(Oreoica gutturalis)*; *c.f.*, K A., sound, noise. | bug-ug-koo |
| 'bagijak : a | native currant *(Acrotriche depressa)* | buggy-juck-er |
| 'bak : a | black snake *(Pseudechis porphyriacus)* | bucker |
| 'balta, 'palta | trousers, coat or shirt; *cf.*, K A., paltapaltarendi, to stretch one's self [one's skin] | bulta, bulter |
| palta | skin cloak | bulta, boolta |
| balja | native fuchsia *(Eremophila maculata)*; *cf.*, K A., palya, a shrub resembling myrtle | bull-yer |
| 'baŋ'ardo | little swamp bird ("hopping jennies"; live along swamps; have black breasts) | bung-ar-roo |
| 'pandala | back-bone | |
| 'bandauri | gun (a dangerous thing, one that killed) | bun-dow-ree |
| 'panjanitj | tell him | bunyer-nitch |
| 'panjaworta | daylight (broad), daybreak; *cf.*, K A., panyiworta, daybreak, morning | bunyer-wurta |
| banjiwarta | | |
| banji | morning, this morning | buntee |
| 'bap : i | father | bup-pe |
| bara | hole | |
| parabara | native peach *(Eucarya acuminata)* | |
| parluni | death (a dead man) | barl-loonie |
| 'barni 'bamani teigani | come here, sit down | |
| 'parnda | stone; *cf.*, K A., parnda, limestone, lime | bunt-ta, ponda |
| 'parnu | yours, *cf.*, K A., parnakko, theirs | burrn-noo |
| 'parnujaŋgana | father's sister (possibly incorrect) | |
| 'parpari | premature child (*lit.*, skin); *cf.*, K A., parpa, skin of the human body | brar-brerry, or brarbrary |
| 'par : a | blackwood *(Acacia melanoxylon)* | burr-ra |
| 'bar'ti | grub boring in stem of wattle | birr-tee |
| 'baru, 'baro | meat | borroo |
| badana | hold fast | |
| 'Badara | A small ancestral man who was killed by ŋarna with a club. *See* ŋarna. | Budderer |
| pat : ana | many, much, all; full of | butten-er |
| bi : paru | brown hawk *(Ieracidea berigora)* | be-e-burrow |
| 'bilta | common opossum *(Trichosurus vulpecula)*; *cf.*, K A., pilta, opossum | bill-ta |
| 'pilta | hip; *cf.*, K A., pilta = hip, side, and opossum | bill-ta |
| 'piltaku | a camp; *cf.*, K A., bulto = place | bilduckoo |
| 'pilta-balta | opossum-skin rug | bilta-bulter |
| biŋku, piŋku | pinkie, rabbit bandicoot *(Thalacomys lagotis)*, "has hook on his tail; he hooks himself on ground while he digs; lives in burrow"; *cf.*, K A., pingko, a small animal with a white tail that burrows in the earth | bing-coo |
| 'pinti | wind | binty |
| pindira, 'kudnju | whitefellow; *cf.*, K A., pindi, white-man; kuinyo = dead person, also a ghostly being | bindra, good-inyoo |
| 'pindranki | white women; *cf.*, K A., pindi, ngangki, white-man female | bin drunkie |
| 'pira | moon | birr-ra |
| 'pira | mutton-fish *(Haliotus)*; *lit.*, moon | birra |
| 'pira | land-shell; *lit.*, moon | birr-roo, birra |
| 'biradja | baldhead; *cf.*, K A., piripiri, old, past child bearing; burka = old | birry-ger |
| 'bir : u | silver gull *(Larus novae-hollandiae)* | biroo, bith-roo |
| 'bitjila | forked stick, used in making native hut | bid-jer-la |
| 'bidnu | Jew-lizard *(Amphibolurus barbatus)* | bid-noo |
| 'bit : i | intestines, entrails | bitt-tee |
| 'biju | smoke (tobacco or wood smoke), a pipe | bee-yoo |

## GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'bulka | grey-haired man, old; *cf.*, K A., burka, old, of age, etc. | bullka |
| 'bulka aŋki | old woman | |
| 'Bulgawan | A wicked old woman who fished at 'Pandalawi; she became turned to stone there. | |
| | "travelling" | bull-away |
| 'bultu | track (spoor, mark) | bool-too |
| 'puljoli | black or dark, dark-haired; *cf.*, K A., pulyona, black | bull-yooly |
| ? buntu | common reed *(Phragmites communis)*; used in making mats; natives learned it from a Coorong woman when informant was a little girl; never before; "we made nets of native flag." | boon-poo, boon-too |
| 'puntu, buntu | A broad-leafed flag or reed, the fibres of which are used in making fish nets. | |
| 'bundunja | death adder *(Acanthophis antarcticus)*; *cf.*, K A., pandonya, a species of goana | boon-dun-ya |
| 'burku | dew; *cf.*, K A., burko, dew | boork koo |
| 'burlai | two; *cf.*, K A., purlaitye, two | bull-i |
| 'budala | gum from wattle trees; sweet; gather and eat it from 'kundaraka trees, growing near Moonta | |
| buda-buto | *lit.*, full of ashes, meaning full of bones; bony bream *(Nematolosa erebi)* | booda-buttoo |
| 'pudara | bush, a small sandhill species | bood-ara |
| budla | calf (of leg) | bood-la |
| 'budli, 'pul:i | star; *cf.*, K A., purle, star | bool-lee |
| 'budni | mallee fowl *(Leipoa ocellata)*; *cf.*, K A., budni | bood-ne |
| 'put:i, but:i | hairy, hair on animals; *cf.*, K A., puti = hairy | booty |
| 'bud:ili | hairy (on animals only); *cf.*, K A., puti, hairy | bood-a-lee |
| 'bu:a | blowfly | boo-wa |
| da | tooth | |
| da:bara | *lit.*, teeth hole; mouth (no name for chin or jaw, all included in mouth); *cf.*, K A., ta, mouth | thar-burra |
| 'ta:jukuli, ta-jukuli | flounder *(Rhombosolea flesoides)* *(lit.*, crooked mouth) | thabarayoogooly |
| Ta:jukuli | Name of a man who had a crooked mouth; it became twisted because he lay out in the moonlight. | |
| 'takari | tomorrow | tukeree |
| 'talbu | a gap; a space between adjacent clumps of trees | |
| 'dalti | ear; *cf.*, K A., tarlti, wing | tul-tee |
| 'dalti 'bit:i | "long ears"; rabbit (introduced) | thurrueta-bitty |
| tam:uli | mother's father (female speaking) | |
| 'daŋka | liver; *cf.*, K A., tangka, liver | |
| 'dan:i | sea, surf | |
| 'dabap:o | bung-eye fly and common fly *(Musca)*; *cf.*, K A., tappo, fly | dab-bup-poo |
| 'darga'ri | tomorrow; *cf.*, K A., tarkarri, future | |
| 'darni-mudlu | toado, toad fish *(Spheroides pleurogramma)*; *cf.*, K A., tarni, surf, mudla, nose | dunny-mood-loo |
| 'dar:a | string; *cf.*, K A., tarra, string | turr-ra |
| 'dawo | a gap or cutting; any crack; *cf.*, K A., tau, hole | thow-woo |
| 'deigani | sit down | tha-gunny |
| 'dia | tooth | dee-ya |
| 'tiarti | pied oyster-catcher *(Haematopus ostralegus)*; *lit.*, sharp; *cf.*, K A., *tiarka*, sharp | deer-de |
| 'dia-tutala | toothache *(lit.*, tooth growl or in bad temper) | deeya doodala |
| dikibar:a | armpit; *cf.*, K A., tiki, rib | thig-gi-burra |
| dilali | red, fair, fair-haired | dill ar-ly, or thil-lully |
| diltja | tendon; *cf.*, K A., tiltya, vein, sinew | tilt-ya |
| 'dim:e'ra | bed | dim-ara |
| 'dinditja | straight | din-dij (dindidge) |
| dinti-woŋkani | impudence *(lit.*, to talk in the daytime) | dinny wonganna |
| 'didna | foot; *cf.*, K A., tidna, foot | didna |

# GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| 'didna-piri | toenails | didna-birry |
| 'diti'dilja, 'didi'deilja | restless flycatcher *(Seisura inquieta)* | did-e-dilya |
| dit : i | white-breasted sea-eagle *(Haliaetus leucogaster)* | |
| djindu-kambalaratj | sunrise; *cf.*, K A., tindo kambarendi, to be hot sun | tintoe-gumble-urrage |
| djindu kambanitj | sun burnt | |
| 'tjindu, djintu | sun; *cf.*, K A., tindo, sun | tin-too |
| 'tjununtju | white-browed babbler *(Pomatostomus superciliosus)* | joon-nun-choo |
| duk : utja | small; *cf.*, K A., tukkutya, small, little | doog-idge |
| 'tumbula | marchfly *(Tabanus)*; *cf.*, K.A., tuburra, a species of large fly | doom-bulla |
| dunka | bad smell | |
| 'tundura | tea-tree *(Leptospermum coriaceum)* | doon-dra |
| 'duru-'bunbuli | hump-backed man | toora boon ballee |
| 'dudla | temper; *cf.*, K A., turla, angry; turlawinko, anger | doodala |
| tudla-woŋkanina | savage talk; *cf.*, K A., turla-warpo, quarrelsome | |
| 'duwa'ra | welcome swallow *(Hirundo neoxena)* | doo-woo-pa |
| 'wainjira, wanjura | Evil spirit which hides in the scrub; makes strange sounds; feared nearly as much as is the nukun : u (Noog-gunner). | wun-yerra |
| 'wakakara | Dtella lizard *(Peropus variegatus)* | wug-a-gurra |
| 'wakak : o | young of wallaby *(Thylogale eugenii)*; *cf.*, K A., wakwakko, child, offspring | wug-ug-coo |
| 'wako, waku | spider; *cf.*, K A., wako, spider | wock-oo |
| 'walgana | fog | wul-gun-nah |
| 'walpa | waterhole, claypan | wulp-pa, wulpa |
| walta, werltau | hot; *cf.*, K A., werltate, a hot season | wurl-to, wol-toe |
| 'wal'da : ro, 'gudil'jaro | lark | wul-durra |
| 'waltja | Australian bustard *(Eupodotis australis)*; *lit.*, long neck; *cf.*, K A., walta, turkey = bustard | wurlt-choo |
| 'walto, 'werlto | neck (or throat) | wurrl-too |
| 'warawara | witch-doctor, sorcerer; *cf.*, K A., warrawarra, doctor, sorcerer | wa-wurra |
| 'waripa'tja | brown goana *(Varanus gouldi)*; *cf.*, K A., paitja, reptile | bunna, warry-but-cher |
| 'war : i | south; *cf.*, K A., worri, extreme point of anything | wurree |
| 'warto | hairy-nosed wombat *(Lasiorhinus latifrons)*; *cf.*, K A., warto, wombat | wurrt-too |
| 'waruka | frog | wurr-ker |
| 'wadibaru | seal (probably *Arctocephalus doriferus)* | waddy-burroo |
| 'watjara | bull-ant | wud-ger-ra |
| 'wadli | hut, "wurley" | |
| 'watbula | bluebush *(Kochia sedifolia)* | whud-bulla |
| 'wauwi | female kangaroo *(Macropus giganteus* var. *melanops)*; *cf.*, K A., wauwe, female kangaroo | wo-wee |
| 'werlto, walto | neck (or throat); *cf.*, K A., werlto, nape of neck | wurrl-too |
| | deep water (long way down) | willa-la |
| widli, wil : i | Australian pelican *(Pelecanus conspicillatus)*; *lit.*, long neck | |
| 'wil : i, 'widli | shallow water | whelp-pa |
| wilpa | daylight (dawn) | whilp-pa, wilpa |
| wiltja | night | will-cha |
| 'wiltjalu, wiltja : lo | night time | |
| wilto | wedge-tailed eagle *(Uroaetus audax)*; *cf.*, K A., wilto, species of eagle | wilt-too |
| 'wina'nak : a | A shrub which creeps about on ground (probably *Kunzea pomifera)*; fruit has strong smell like that of apples. | |
| win : a | net, fishing net; *cf.*, K A., widni, sinew of which the natives make nets | whin-ner |
| win : ara, winara | frost, frosty | whin-ner-rah, winner-er |
| 'winta | barn-owl *(Tyto alba)*; cf., K A., winta, a species of owl | win-ta |
| 'winta | type of spear thrown only by hand, javelin | whin-ta, win-ta |

## GENERAL VOCABULARY

| TINDALE | | JOHNSON |
|---|---|---|
| windar:a | west wind | wind-darra |
| wip:a | red ant | whip-pa |
| wir:a | gum tree, more properly forest of trees, mallee; *cf.*, K A., wirra, wood, forest, bush | whirrah |
| wir:i | waddy, small throwing club | whirry |
| 'wiru | southern stone curlew *(Burhinus magnirostris)* | weer-do |
| widat:a | shark | withut-too |
| wititu, mar:awalpa | native cherry *(Exocarpus cupressiformis)* | whid-dit-too, murra-wulpa |
| 'witja | dry; *cf.*, K A., wityarnendi, to fade, wither | witcha |
| 'widjali | long | wigilly |
| | "snipe" | whil-lee |
| 'witpara | whip-snake *(Demansia psammophis)* | wid-burra, we-burra |
| 'wit:a | stone gecko *(Diplodactylus vittatus)*, small variety | wit-ta |
| 'wid:ara | mallee scrub, scrub | whid-dar-ah, whid-der-ah |
| 'wit:i | "sandpiper," probably the dotterel | whit-tee |
| 'wom:ara | plain | wummerra, wam-mera |
| 'woneidja | to fall down | |
| 'woŋgala | to fall down; to fall suddenly | wong-ala |
| 'woŋgara | head-wind, bad wind *(lit.*, west wind) | wong-gurra |
| wornka | brown snake *(Demansia textilis)* | wurrn-koo |
| jak:ana | sister; *cf.*, K A., yakkana, sister | yug-gun-na |
| jak:ara | spear-thrower | yuckurra |
| 'jak:i-wadli | "down below the hill"; a nice sheltered place; foot of a hill; *lit.*, valley camp; *cf.*, K A., yakki, valley | yuggy wurley |
| jalku | leg, shin; *cf.*, K A., yerko, leg | yalgoo, yalkoo, yal-koo |
| jalku-adjinidji | leg weary | yalgoo-udjini-gy |
| jalku-parto tawara | big short leg, *i.e.*, leg of a European when compared with native ideals; *cf.*, K A., yerko, leg; tawara, large; parto, thick | yalgoo buttoo-dowera |
| jalku-wikili | long-legged | yalgoo wigilly |
| jalku-jukuli | bandy-legged; *cf.*, K A., yerko, leg; yokunna, crooked | yalgoo yoogooly |
| jampu | common dolphin *(Delphinus delphis)*; *cf.*, K A., yambo, large species of fish | yump-poo |
| jaŋar:a | crested tern *(Sterna bergi)* | yun-gurra |
| jaŋgar:a | Painted Dragon *(Amphibolurus pictus)* | yun-gurra |
| janka, jankari, jerkari | moustache, whiskers | yunkkar-ree, yarnker |
| jardli, jerdli | spotted whiting *(Sillaginodes punctatus)* | yurrd-lee |
| jarugareitja | to go around and gather [food] | |
| 'jadli | "humbug" (exaggeration) | yud-lee |
| jau | Pacific Gull *(Gabianus pacificus)*; *cf.*, K A., yao, seagull | yow woo |
| jelki | kangaroo rat *(Bettongia lesueuri)*; *cf.*, K A., yerki, small burrowing animal | yel-kee |
| jel:a-paltari | leggings (new term); *cf.*, K A., yellamuka, calf of leg. | yellow bulteree |
| jerkari, janka | moustache, whiskers | yurrk-ka-re |
| 'jer:i | "I am going after you"; dual; *cf.*, K A., yerra, an indefinite pronoun | yurry |
| 'jerta | the ground, sand; *cf.*, K A., yerta, earth, land | yurr-tur, yut-too |
| jerdli, jardli | spotted whiting *(Sillaginodes punctatus)* | yurrd-lee |
| jerdlo | rough waves (big, rough swell); *cf.*, K A., yerlo, sea | yurd-loo |
| 'juk:u | ship (new term) | yurk-koo |
| 'jukuli, juguli | crooked; *cf.*, K A., yokunna, crooked | yoogooly |
| julara | box-bush *(Bursaria spinosa)* | yoo-ler-ra |
| 'jultu | "a cheeky rogue" | youll-too |
| 'juŋga | brother; *cf.*, K A., yunga, brother | yung-er |

## PHRASE

| TINDALE | | JOHNSON |
|---|---|---|
| Kunara banji takari 'manja | North wind today, tomorrow rainy. | coonara buntee tukeree munya |

## PLACE NAMES

| TINDALE | | JOHNSON |
|---|---|---|
| 'Antini | Jim Barrett's = Balaklava, Section 171, Hundred of Parawurlie. | Un-dın-e |
| 'Awatji | Waterhole near the Telegraph Line; *lit.*, a catfish. Section C, Hundred of Warrenben. | Ower-jee |
| 'Ilarawi | Hillderowie Well of map; *lit.*, dwarf's waterhole. Also localized at Emu Waterhole (Yillow-rowie). | Yillow-rowie, Eela-rowie, Erlarowie |
| Kaliwi | White Hut; *lit.*, dog waterhole. Section P, Hundred of Carribie. | Calloway |
| Kalkaberi | *Lit.*, sheoak country, position uncertain. | Kalkabury |
| 'Kanarap : a | Beach near Penguin Point; opposite Section 11B, Hundred of Warrenben. Natives caught butter-fish there. | Gunner-rapper |
| 'Garimalka | Curramulka township; *lit.*, "emu white," *i.e.*, a limestone waterhole where emus come to drink. | Curramulka |
| 'Karinja | Yorketown; *lit.*, Emu Place. | Gurreena, Gurrina |
| 'Garganja'ka | Cut-cut-culier, or Sparrow-hawk Hill, near White Hut; *cf.*, K A., kurkinya, a small hawk. | Gul-gonuck, or Gurrl-gun-yer-nucka |
| 'Karibi | Carribie Station Well; *lit.*, where emus drink. Section 8a, Hundred of Warrenben. | Carriebie |
| Katja'rawi, 'Kadjarawi | Point Yorke (opp. Section 97, Hundred of Coonarie). | Gud-gerowie |
| Kawi-padla | Alf. McDonald's, Hundred of Parawurlie, *cf.*, K A., kauwe, water; padlopadluna, dying. | Cowie-purdla |
| 'Kokuđawi | Marion Bay, Section G, Hundred of Warrenben. | Cock-a-dowie |
| 'Gula'wul'gawi | A flat area of ground near Cape Spencer. | Gool-a-wool-gowie |
| 'Kulkari | A waterhole where emus come to drink; *lit.*, place where emus made a noise; *cf.*, K A., kalluru, noise; kari, emu. | Gool-gar-ry |
| 'Kulkawi | Old Cadd's near Ilarawi, eastern end of Section 10, Hundred of Warrenben. | Gool-gowie |
| 'Kundarawi, Gundarawi | Dust holes; *lit.*, bad water. Section Z, Hundred of Carribie; *cf.*, K A., kudna + kauwe, bad water. | Goon-derowie |
| 'Ku : bawi | Coobowie township; *lit.*, a ghost. | Coobowie |
| 'Malkabalban (Malka-palpa) | Davey's Fence, Stenhouse Bay jetty. | Mulka-bulba |
| Maltirawalpa | Little Round Swamp Waterholes, Section K., Hundred of Carribie. | Mulderra wulpa |
| 'Mankara | Tuckok-Cowie, Section 211, Hundred of Moorowie; *lit.*, young woman. | Mun-gurra |
| 'Manka'warli | Section 53, Hundred of Melville. | |
| 'Madpa'rawi, 'Madbu'rawi | A flat near the Old Gypsum Bins, Marion Bay (really the waterhole there); *cf.*, K A., matpo, venereal disease (perhaps yaws); dawi, water. | Mud-borowie |
| 'Manbi'wi | Point Davenport | |
| Minlakawi | Fresh water well. Section 8, Hundred of Minlacowie). | Minlacowie |
| 'Mu : rawi | Port Moorowie. | |
| Nanto-warli | *Lit.*, Kangaroo Hut, Minchin's Hut, Section 6c, Hundred of Warrenben. | Nanto wurlie |
| 'Nantuwaru | South Hummocks Range; *lit.*, kangaroo language; the place where the kangaroo people live. | Nanto-warra |
| 'ŋaljawi | Little Scrub Hut, Hundred of Warrenben; *lit.*, quiet place. | Nul-yow-wee |
| 'ŋan : ep : a | Corny Point. | An-ne-pa |
| ŋarna | Royston Head. | Narrn-noo, Arna |

# PLACE NAMES

| TINDALE | | JOHNSON |
|---|---|---|
| 'Nudjali | Pipeclay Well, east of Section K, Hundred of Carribie; Daly Head; *lit.*, pipeclay = 'nudjali. | Mood-jully |
| ŋurikawi | Wattle Springs, Section 56 H, Hundred of Parawurlie. | More-a-cowie (also corrupted to Orrie-cowie) |
| | Rhino Head. | |
| 'Nildi'djari Niltidjeri | Lagoon north of Cable Hut. | Nilder-girrie |
| Bananta | Sturt Bay. | Bun-un-too |
| 'Bantalawi, Pandalawi | Stony waterhole; *lit.*, limestone water. Water Reserve No. 2, Hundred of Warrenben. Parnda, limestone; kauwe, water. | Pondalowie |
| Babladawi | *Lit.*, where young men are circumcised. | Bubladowie |
| Bablikawi | Brackish waterhole. Section 351, Hundred of Dalrymple. | Bubla-cowie |
| 'Pararmarati | Edithburgh. | Barrarm-marrattee |
| Parawarli | West Cape; *lit.*, plenty of meat. High bluff on Section 26b, Hundred of Warrenben. | Para-wurlie |
| 'Pingalti | Peesey Hill, Section 222, Hundred of Moorowie. | Bin-gultie |
| 'Puljakara | The Dairy, Section 147, Hundred of Carribie. | Bull-yer-gurra |
| Punpu | Point Turton; flat near Point Turton. | Boon-poo |
| 'Taliwonko | Lake Sunday, north-west of Yorketown. | Tally-wonkko |
| Takok : awi | Section 211, Hundred of Moorowie; *lit.*, boggy watering place. | Tucock-cowie |
| 'Wadjalawi | West of Point Davenport. | |
| 'Wak : uli | North-eastern end of Section 2, Hundred of Coonarie. | |
| 'Waluri | Daly Head. | |
| Waltuwirra | Old man Jolley's; *lit.*, gap in the forest; *cf.*, K A., waltu, space, neck; wirra, forest, trees. | Wald-o-wirra |
| 'Wan : a'nawi | Jim Brown's Waterhole. Water Reserve No. 1, Hundred of Warrenben. | Wun-un-owie |
| 'Waril'bin | Waterhole, Section 20 of Hundred of Warrenben; *lit.*, windy; *cf.*, K A., warri, wind; binna, adult, big. | Warrin-ben (now Warren-ben) |
| 'Wili'badla | *Lit.*, pelican creek. Beach north of Jim Brown's, Section 3a Hundred of Warrenben. | Willie-bulla, Wildy-bulla |
| 'Winta : nja | Cottar's Swamp, near Section 152, Hundred of Parawurlie. | Win-tan-ya |
| 'Wiru'ka, Wir : uka | Warooka township; *lit.*, muddy waterhole. | Warooka, Weer-rooka |
| Wit : u | Sandhill Waterhole; *lit.*, white sandhills. | Whit-too |
| 'Wok : uli | Sandy Point Well, Section 24, Hundred of Coonarie. | Wock-oo-lee |
| 'Wordaŋ | Wardang Island. | |
| 'Wurawi | Big Scrub Hut (Gumtree Waterhole), near Sturt Bay. | Woorowie |
| Jaliwi'rawi | Cottar's Castle, Section 157, Hundred of Parawurlie. | |
| Janantu | Swivel Hut; south-east corner of Section 4d, Hundred of Warrenben. | Yu-nun-too |

# ANALYTICAL NOTES ON A SAMPLE OF BROWN COAL FROM THE BALAKLAVA-INKERMAN DEPOSIT.

*BY W. TERNENT COOKE, D.SC., A.A.C.I.*

**Summary**

About 25 bores have been sunk on the Balaklava-Inkerman deposit of brown coal, and the results of partial analysis of the samples are to be found in the official publications of the State Department of Mines ( 1 ) . Unfortunately, official samples are apparently no longer available. The sample, about 16 grammes, on which the following tests were made, was obtained from a private source, but the donor was unable to state from which bore it was obtained.

# ANALYTICAL NOTES ON A SAMPLE OF BROWN COAL FROM THE BALAKLAVA-INKERMAN DEPOSIT.

By W. Ternent Cooke, D.Sc., A.A.C.I.

[Read June 9, 1936.]

About 25 bores have been sunk on the Balaklava–Inkerman deposit of brown coal, and the results of partial analysis of the samples are to be found in the official publications of the State Department of Mines (1). Unfortunately, official samples are apparently no longer available. The sample, about 16 grammes, on which the following tests were made, was obtained from a private source, but the donor was unable to state from which bore it was obtained.

As received it was a finely divided very dark brown powder, much darker than say the bulk coal of, e.g., the Noarlunga deposit. It showed the usual chemical reactions for brown coal, attack by cold nitric acid, and solubility in alkali. The ash content of the sample is very high, 23% on the dry basis, a figure in marked contrast to many of the officially published results; thus, the average ash content of the field is about 15%, reckoning on a dry basis (2). The equilibrium moisture content of the material, under ordinary atmospheric conditions is 8 to 10%; the official figure is 16·6% (2).

The following analytical results, with one or two minor exceptions, are the mean values of at least two determinations. The lack of material precluded the carrying out of distillation tests.

## Sulphur Distribution.

Applying Powell's method (3), but grouping "sulphate" and "pyritic" sulphur together, there was found:—

| | | |
|---|---|---|
| *(a)* | Total sulphur - - - - | 3·54% |
| *(b)* | Sulphate + pyritic - - - | 1·49% |
| | Organic, Calc. $(a-b)$ - - - | 2·05% |
| | Organic, found - - - - | 1·82% |
| | Fe, (as $FeS_2$) equivalent to (b) - | 1·30% |
| | Fe, found - - - - | 1·23% |

## Proximate Analysis.

| Volatile Matter. | Fixed Carbon. | Ash. |
|---|---|---|
| 40·20% | 41·85% | 17·95% |

The ash contains 13·4% $SO_3$.

## Calorific Value.

This was found to be 9,283 B.T.U. per lb. for the dry material (4). The official figure for material with 16·5% of water is 8,150 (2), which calculated to dry material is 9,760. Applying Parr's formula (5), using the figures 3·54% sulphur and 23·04% ash, one obtains the value 12,430 B.T.U. for "unit coal"; this figure places the coal in the class "brown lignite." Of the various formulae tried for calculating the heating value from analytical data, Dulong's gave 9,652, Inchley's (6) 9,872, Schreiber's (7) 9,517.

## Complete Analysis.

Combustion of the coal gave 57·1% carbon, 3·54% hydrogen, and 23·04% ash. The ash, however, contains 21·33% of $SO_3$. Correcting for this and inserting the value 3·54% total sulphur, one obtains:—

| Carbon. | Hydrogen. | Sulphur. | Difference. | Ash. | Carbon/Hydrogen. |
|---|---|---|---|---|---|
| 57·10% | 3·54% | 3·54% | 17·70% | 18·12% | 16·1% |
| 69·72% | 4·32% | 4·32% | 21·62% | — | — |

## The Ash.

This was found to contain:—

| $SiO_2$. | $Al_2O_3$. | $Fe_2O_3$. | CaO. | MgO. | $SO_3$. | Diff. |
|---|---|---|---|---|---|---|
| 36·16% | 12·00% | 7·64% | 7·28% | 7·46% | 21·33% | 8·13% |

Detectable amounts of phosphate and titania are present. The 21·33% of $SO_3$ accounts for about 55% of the total sulphur in the coal; the high content of lime and magnesia is responsible largely for this retention of sulphur.

## References.


1. Beginning with Mining Review No. 37, Department of Mines.
2. Mining Review, No. 60, 1934.
3. U.S. Bureau of Mines, Technical Paper, No. 254, 1921.
4. The author is indebted to the Animal Nutrition Laboratory for kindly carrying out this estimation.
5. Jour. Industrial and Engineering Chem., **vol. xiv,** 1922, p. 921.
6. Mitchell, "Fuel Oils," p. 46.
7. Brit. Chem. Abs. B., 1932, p. 166.

# THE ARTRACOONA METEORITE.

*BY A. W. KLEENMAN, M.SC.*

**Summary**

The Artracoona meteorite is an aerolite from the north-east of South Australia. It was found in 1914 by Mr. G. Amesbury on the Carraweena Run, eight miles north-west of the Old Carraweena Head Station and six miles west of Artracoona Hill. The station is situated on the Strezlecki Creek and is in 29' 11' south latitude and 139' 59' east longitude. Mr. Amesbury, in a letter, says that it was "lying exposed on the side of a sandhill. It might have been' buried for years and then uncovered, as that country drifts in dry seasons." This meteorite is thus very close to two other meteorites, the Carraweena, found six miles south-east of the Head Station, and the Accalana from Accalana Wells, six miles south of the Head Station. All three are stony and are very similar in appearance. The two latter are being described by Dr. A. R. Alderman, in a paper to be printed in the Memoirs of the South Australian Museum, and a locality map is to be given in which the position of all three will be shown.

# THE ARTRACOONA METEORITE.

By A. W. Kleeman, M.Sc.

[Read June 11, 1936.]

Plate IV.

The Artracoona meteorite is an aerolite from the north-east of South Australia. It was found in 1914 by Mr. G. Amesbury on the Carraweena Run, eight miles north-west of the Old Carraweena Head Station and six miles west of Artracoona Hill. The station is situated on the Strezlecki Creek and is in 29° 11′ south latitude and 139° 59′ east longitude. Mr. Amesbury, in a letter, says that it was "lying exposed on the side of a sandhill. It might have been buried for years and then uncovered, as that country drifts in dry seasons." This meteorite is thus very close to two other meteorites, the Carraweena, found six miles south-east of the Head Station, and the Accalana from Accalana Wells, six miles south of the Head Station. All three are stony and are very similar in appearance. The two latter are being described by Dr. A. R. Alderman, in a paper to be printed in the Memoirs of the South Australian Museum, and a locality map is to be given in which the position of all three will be shown.

The stone, when acquired by the University of Adelaide, weighed 45 lbs. 14 ozs., or 20,810 grams. This is probably the whole of the meteorite, except for some small pieces that were chipped off by Mr. Amesbury before he was aware of the nature of the body. It is a well orientated stone and stands on a flat trapezoidal base, 31 centimetres across the longer diagonal. [See plate IV.] The four sides converge towards a common peak about 21 centimetres above the base. There is over the whole of the surface of the stone a dense dark brown skin about a millimetre or so in thickness. Above this, but not continuous over the whole, is a light brown coating caused by terrestrial weathering. The inner skin is missing from the peak and seems to have been removed by the impact with the ground.

The stone is compact and the chondri break with the matrix. When viewed on a broken surface it is a dark-brown in colour and, to the naked eye, almost aphanitic, the only visible structure being the light-brown chondri 1 to 2 mm. in diameter. Examination with a simple lens reveals small patches of nickel-iron.

The microscope shows a granular stone in which there are some chondri. The most obvious feature is the great amount of haematite present. It is in indefinite veins and impregnating cavities and cracks between the individual grains. The other ferrous minerals are metallic nickel-iron and pyrrhotite. The nickel-iron is shiny and silver-white in colour, and the pyrrhotite is bronze-yellow. Both minerals occur as small grains and as aggregates. The silicates are hypersthene, olivine and plagioclase. They are granular and rarely show the proper crystal form except in some of the chondri. Most of the grains range from 0·1 to 0·4 mm. diameter, but there are some, a smaller generation, below 0·05 mm. The chondri are of three types and average 0·8 to 1·0 mm. across.

The most prominent of the silicates are hypersthene and olivine. Both are nearly colourless and both have a moderate birefringence and an optic axial angle close to 90°, and it is well-nigh impossible to distinguish them in random section.

However, the analysis shows the presence of both the meta- and ortho-silicates, and in some of the chondri crystals show their characteristic crystal form. The axial angle of the olivine is 80° to 85°, and it is negative in sign. That of hypersthene is closer to 90° and the sign is indeterminate.

The plagioclase is not readily distinguishable and has been inferred rather than specifically determined. It has a low birefringence and almost straight extinction parallel to the elongation and to the cleavage. It is distributed through the stone as small grains and, in addition, often forms chondri. The extinction angles suggest the composition of basic oligoclase, and this observation is borne out by the value, $Ab_{65}An_{35}$, calculated from the analysis.

One of the most common types of chondrus is that in which large idiomorphic crystals of olivine are set in a matrix of indeterminate silicate. Another common type is that composed of laths of hypersthene radiating from a point eccentric to the centre of the chondrus. There is usually some dust between the laths. Many of the chondri consist of felspar; in one type there are a number of parallel laths of felspar, and the other is composed of one large crystal of felspar enclosing innumerable brown inclusions.

The structure of the stone apart from the chondri is granular and without any special relations between the various minerals. It is compact and dark brown and contains light chondri which break with the matrix. In the Rose-Tschermak-Brezina System it would be designated as Black Chondrite (Cs).

The Specific Gravity is 3·52.

The bulk analysis, as made by the writer, is as follows:—

| | | | |
|---|---|---|---|
| $SiO_2$ - - | 37·80 | $P_2O_5$ - - | 0·22 |
| $Al_2O_3$ - | 4·21 | $NiO$ - - | 0·13 |
| $Fe_2O_3$ - | 7·64 | $CoO$ - - | tr. |
| $FeO$ - - | 12·48 | $Cr_2O_3$ - | 0·51 |
| $MgO$ - - | 23·43 | $CO_2$ - - | 0·42 |
| $CaO$ - - | 1·77 | C - - | 0·04 |
| $Na_2O$ - - | 1·14 | FeS - - | 5·50 |
| $K_2O$ - - | 0·10 | Fe - - | 1·68 |
| $H_2O+$ - | 1·80 | Ni - - | 0·10 |
| $H_2O-$ - | 0·50 | | |
| $TiO_2$ - - | n.d. | | 99·47 |

In this analysis Mr. A. F. Pilgrim determined the total carbon by combustion, and the value for free carbon was found by subtracting the value for combined carbon from the result so obtained. The value for ferrous iron is approximate only. It was determined by the modified Pratt Method(1) on a sample from which all of the free iron and most of the sulphide had been removed by a magnet. Allowance was made for the iron in the sulphide still left in the sample, but no allowance was made for the reducing effect of the 0·5% of sulphur.

In order to obtain the approximate amount of the various silicates present the non-magnetic portion was separated into two portions, one soluble in hydrochloric acid and the other insoluble in acid. The analyses of the two portions are set out below, and in them the proportions of the various oxides are given as percentages of the total composition of the meteorite.

(1) Washington, H. S., "The Chemical Analysis of Rocks," New York, 1930, pp. 213-217.

(1) Portion insoluble in acid:—

| | | | | |
|---|---|---|---|---|
| $SiO_2$ | 24·62 | Orthoclase | 0·56 | |
| $Al_2O_3$ | 3·90 | Albite | 9·45 | 14·73 |
| FeO | 3·83 | Anorthite | 5·28 | |
| MgO | 7·42 | Hypersthene (Fs) | 6·86 | 25·56 |
| CaO | 1·43 | (En) | 18·70 | |
| $Na_2O$ | 1·14 | $CaSiO_3$ | 0·70 | |
| $K_2O$ | 0·10 | $SiO_2$ | 0·84 | |

The orthoclase is, no doubt, in solid solution in the plagioclase. The calcium metasilicate is part of the pyroxene. The excess of silica is probably some that was rendered insoluble in the dissolving of the acid-soluble portion of the sample.

(2) Portion soluble in acid:—

| | | | | |
|---|---|---|---|---|
| $SiO_2$ | 10·83 | Forsterite | 25·36 | 28·01 |
| $Fe_2O_3$ | 20·13 | Fayalite | 2·65 | |
| MgO | 14·73 | Ferrous Sulphide | 1·48 | |
| CaO | 0·20 | Iron Oxides | 16·79 | |
| $CO_2$ | 0·42 | Magnesite | 0·50 | |
| S | 0·51 | Calcite | 0·35 | |

The magnetic portion also contained some silicate, but this has been assumed to have the same composition as the non-magnetic. The several analyses recalculated to 100% give the following mineral composition:—

| | | | |
|---|---|---|---|
| Olivine | 29·5 | Ferric Oxides | 17·7 |
| Hypersthene | 27·5 | Carbonates | 0·9 |
| Plagioclase | 16·2 | Nickel-Iron | 1·8 |
| Ferrous Sulphide | 5·5 | Chromite | 0·8 |

The hypersthene has the composition $MgSiO_3 : FeSiO_3 = 73:27$. In the olivine the ratio $Mg_2SiO_4 : Fe_2SiO_4$ is 9:1. These compositions agree well with the optical properties of the minerals. The presence of a considerable amount of carbonate can be taken as an evidence of terrestrial weathering. This is borne out by the fact that some of the nickel is in the non-magnetic portion and is presumably in the oxidised condition.

The stone is thus one of the class in which a small amount of nickel-iron is present in a stony base. The mineral composition is that normal to the meteorites of this type, but owing to the weathering the ratios of nickel to iron and of nickel-iron to the whole are too unreliable to be significant.

Department of Geology, University of Adelaide.

# REMARKS ON THE NEMATODE, GONGYLONEMA PULCHRUM.

*BY PROFESSOR T. HARVEY JOHNSTON, M.A., D.SC.*

**Summary**

In February, 1936, a nematode was received for identification from Dr. W. Gilmour, Director of the Pathological Laboratory, Auckland Hospital, together with a statement that it had been taken from the tissue immediately under the inner surface of the upper lip of a Jugo-Slav living in New Zealand. The specimen was submitted by Dr. T. H. Pettit, Auckland, and the circumstances associated with the case are being published in the New Zealand Medical Journal (Johnston, 1936).

# REMARKS ON THE NEMATODE, GONGYLONEMA PULCHRUM.

By Professor T. Harvey Johnston, M.A., D.Sc., University of Adelaide.

[Read May 11, 1936.]

In February, 1936, a nematode was received for identification from Dr. W. Gilmour, Director of the Pathological Laboratory, Auckland Hospital, together with a statement that it had been taken from the tissue immediately under the inner surface of the upper lip of a Jugo-Slav living in New Zealand. The specimen was submitted by Dr. T. H. Pettit, Auckland, and the circumstances associated with the case are being published in the New Zealand Medical Journal (Johnston, 1936).

The worm proved to be *Gongylonema pulchrum* Molin, 1857, which is normally a parasite of the submucosa of the upper half of the digestive tract of sheep, cattle and pigs, occurring more frequently in the oesophagus in the first and second, and in the tongue region in the pig.

This species seems to have been recorded from human beings on seven previous occasions, the first two from Italy, and the remaining five from the south-eastern portion of the United States.

In 1864, Pane briefly described as *Filaria labialis* an obviously immature female worm taken from a small pustule on the inner surface of the upper lip of a medical student in Naples. The parasite was 30 mm. long, with the vulva and anus situated at 3 and 0·5 mm., respectively, in front of the end of the short club-like tail. Pane's description and main figure were republished by Leuckart (1876, 616-7), who stated that the position of the female aperture was more like that in Strongylidae, though he retained the species under *Filaria* provisionally. Leuckart also drew attention to Leidy's very brief account (1850, 117) of *Filaria hominis oris* from a human lip (? locality), but he regarded the two as distinct, probably correctly. Leidy thought that his parasite may have been the male of *Filaria medinensis*, but some later authors have suggested it may have been a Mermithid. Its dimensions (length, 140 mm.) and the form of the posterior end seem to exclude it from *Gongylonema pulchrum*. A summary of Pane's account was given by Davaine (1877, CVII), Cobbold (1879, 207), Blanchard (1890, 14), Braun (1903, 275; 1906, 305); Parona (1911, 321). Fantham, Stephens and Theobald (1916, 407) gave the same information as Braun but called the parasite *Agamofilaria labialis;* as also did Castellani and Chalmers (1913, 522; 1919, 641). Sambon (1925, 49; 1926, 251) referred to Pane's record, republished his figure and identified the parasite as having been, most probably, *Gongylonema pulchrum*. Yorke and Maplestone (1926, 314) listed it as *G. labiale*, though they remarked that Baylis (1925) regarded it, along with several other species, as a synonym of *G. pulchrum*.

In 1908 Tecce reported taking from a small tumour on the finger of a young man in Italy a female worm 13 cm. long and one millimetre wide. It was handed to Pierantoni, who identified it as *Filaria labialis* Pane and described and figured it (1908). A brief abstract of these two papers was published by Parona (1911, 465 and 367, respectively). I have not seen Pierantoni's account, but it seems unlikely that a parasite of such a length taken from the subcutaneous tissue of a finger would be *Gongylonema pulchrum*. I have, accordingly, refrained from including this record in the number of reported cases of undoubted *Gongylonema* from man. Castellani and Chalmers (1913, 522; 1919, 64) mentioned Pierantoni's reported occurrence of the parasite.

The second record was that by Alessandrini (1914, 42), who reported having examined several worms extracted from tunnels in the submucosa below the tongue of a girl near Rome. He recorded them as belonging to a new species, *Gongylonema subtile*, resembling *G. pulchrum*. He had previously (1908, 163) recognised *G. scutatum* as occurring in Italian sheep and cattle. Sambon (1925, 69; 1925, 315) referred to Alessandrini's case, and published notes (1926, 254) supplied by Carega, the physician who first drew attention to it. Sambon reported the parasite to be *G. pulchrum*, this identification being due to Baylis (1925, 361), who reported, after examining Alessandrini's specimens, that *G. subtile* was a synonym of *G. pulchrum*.

The next to record the parasite from human beings was Ward (1916), who gave a detailed account of a specimen taken from the lower lip of a girl in Arkansas, U.S.A. He regarded it as being probably *G. pulchrum*, his figures being republished by Brumpt (1922). Ward suggested that *Filaria hominis oris* might possibly have been *G. scutatum*, but thought it improbable because Leidy was an acute observer who was hardly likely to miss the prominent cuticular bosses which occur anteriorly in species of *Gongylonema*.

It was Stiles who reported the next two cases; one from the lower lip of a woman in Florida (1918, 64; 1920, 200; 1921, 197); and the other from the back of the mouth of a woman in Georgia (1921, 197; 1921, 1,177). The Florida worm was regarded as either *G. pulchrum* or *G. scutatum*. In the account of the case from Georgia, it was recognised that the parasite resembled *G. pulchrum*, but Stiles thought it advisable to name it as a distinct species, *G. hominis*, until mature specimens of human origin should be available to allow comparison with the worm occurring in the pig. The three North American cases to date were regarded by him as relating to *G. hominis*. Brumpt (1922, 637) placed the latter as a synonym of *G. pulchrum*.

Ransom (1923, 244) made brief reference to the finding of an immature female in the mucosa of the mouth of a man in Louisiana. Stiles and Baker (1929, 221; 1928, 1,891) recorded another case, this time from the mouth of a girl in Virginia, the worm being called *G. hominis* rather than *G. pulchrum* because of the doubt regarding the identification of the species from pigs in U.S.A.. Chapin (1922) had previously described the parasite of North American pigs as a distinct form, *G. ransomi*, though this name was definitely synonymised with *G. pulchrum* by Baylis (1925) and Lucker (1932, 134), the latter having re-examined Chapin's material.

The present case from a man in Auckland, New Zealand, constitutes the eighth recorded from human beings. The worm was a female, 58 mm. long, 0·33 mm. in diameter, and had just reached maturity, since it contained abundant fertilised eggs, while within the vagina was a single egg (0·059 by 0·035 mm.) with a well-developed, typical, thick shell and a coiled embryo. The vulva and anus were situated at 1·93 and 0·22 mm., respectively, from the bluntly rounded tip of the narrowed tail. The dimensions agree closely with those given by Baylis (1925, 362) and other investigators.

The relationships of the genus have not yet been settled. Originally placed in the Filariidae, Hall (1916, 190) transferred it to a new subfamily, Gongyloneminae, belonging to the Spiruridae. This classification is that accepted by Yorke and Maplestone (1926, 312), Cram (1927), Rauther (1930), and Sprehn (1932). Nicoll in 1927 emended the name to Gongylonematinae. Baylis and Daubney (1926, 217) considered the subfamily was unnecessary and placed the genus under Arduenninae. Baylis (1929, 233) mentioned that the genus showed certain affinities with the latter subfamily. Chitwood and Wehr (1932, 168; 1934,

313) regarded the Gongylonematinae as a valid group but placed it under Thelaziidae.

Some authors quote the type species as *G. minimum* Molin; others regard it as *G. musculi* (Rud.) Neumann. The former group includes Ransom, 1911; Yorke and Maplestone, 1926; Sambon, 1926; Cram, 1927; Rauther, 1930; Chitwood and Wehr, 1934; and Sprehn, 1932. The latter group comprises Neumann, 1894; Hall, 1916; and Baylis and Daubney, 1926. Since Rudolphi (1819) did not describe his *Filaria musculi* but merely mentioned its presence in the stomach and liver of the mouse and listed it as a doubtful species, several authors have regarded it as a *nomen nudum*. Because Molin placed it as a synonym of his own name, it seems best to consider it validated by such action, so that the type of the genus would be *G. musculi,* as described by Molin. It has been suggested that Rudolphi's specimen from the liver may have been *Hepaticola* Hall (1916); Sambon (1926, 251-2, 261, 264).

The anatomy of *G. pulchrum* has been described by Stiles (1892) under *Myzomimus scutatus;* Neumann (1894), Ransom (1911, 100) and Seurat (1916) under *G. scutatum;* Chapin (1922) and Hall (1924, 120) under *G. ransomi;* Baylis (1925, 47-51) and Hall (1924, 118) under *G. pulchrum.* A summary, usually accompanied by figures, has been given under either *G. scutatum* or *G. pulchrum,* by various workers, including Brumpt (1922), Baylis (1929), Faust (1930), Sprehn (1932), and Neumann (1905). Tabulated measurements of *G. scutatum, G. ransomi, G. pulchrum,* and *G. neoplasticum* were published by Baylis (1925, 72-74). The recent treatises on the parasites of domesticated animals, by Mönnig (1934) and Cameron (1934), and those of pigs by Hall (1933), are not yet available in Adelaide.

The life history of *G. scutatum* was investigated by Ransom and Hall (1915), who found that a number of species of dung beetles *(Aphodius; Onthophagus)* were suitable intermediate hosts in the United States, the larval stage of the worm being found in the body cavity of the adult and larval stages of these insects. The cockroach, *Ectobia germanica,* was also proved to be able to serve as an intermediate host, eggs of *Gongylonema* from cattle and from pigs having been used for the experimental infections. Attempts to infect a pig with larvae of ruminant origin, the cockroach being used as the intermediary, failed, this failure being regarded as supporting the view that the pig parasite is specifically distinct from that occurring in sheep and cattle. Sheep were infected experimentally by larvae from a cockroach, but developed from worms from cattle. About three months elapsed between infection and maturity in the sheep. Attempts to infect a rabbit and a guinea pig failed. A period of about a month was required to complete the larval stages in the cockroach. These authors showed that the life history was similar to that made known for *G. neoplasticum* of rats, by Fibiger and Ditlevsen (1914), who reported that three species of cockroaches *(Periplaneta americana, P. orientalis, Ectobia germanica)* as well as the meal worm, *Tenebrio molitor,* could serve as intermediaries, while the adult stage could be developed in the two common rats, *Epimys norvegicus* and *E. rattus,* as well as in the mouse, rabbit and guinea pig.

Seurat (1916) thought that some of the larvae from coprophagous beetles, described by Ransom and Hall (1915) as *G. scutatum,* belonged to another species, but these latter authors (1917) brought forward evidence to support their earlier contentions and stated that the larvae which Seurat regarded as those of *G. scutatum* belonged to some other *Gongylonema.*

Baylis, Pane and Sambon (1925) were successful in transmitting *G. pulchrum* of ruminants to rats. They reported the parasite to be common in cattle in parts of Italy, and obtained the larval stages from four species of coprophagous beetles, but cockroaches were not found to be infected naturally. One species of the

latter, *Blattella germanica*, could be readily infected artificially, but these authors failed with *Blatta orientalis*. They published figures of the insect hosts and of the larval parasites. Blair (1925; 1926) referred to the finding of these larvae in the following scavenging beetles in Italy—two species of *Onthophagus*, and one each of *Caccobius*, *Aphodius* and *Oniticellus*. Sambon (1926, 257-61) mentioned these coleopterous hosts as well as the cockroach, *Blattella germanica*, and published figures of them as well as of the larvae found in them. Baylis had stated previously (1925) that *G. scutatum*, amongst others, was a synonym of *G. pulchrum* and had suggested (1925, 75) that *G. neoplasticum* might also belong to the same species. This view was controverted by Leiper (1926, 56; 1926, 70), who published two papers in 1926, adversely criticising the views of Sambon (1925) regarding *Gongylonema* as a possible cause of cancer in humans, and those of Baylis (1925) relating to the synonymy of *G. pulchrum*. Leiper considered the latter, *G. scutatum* and *G. neoplasticum* as distinct species. He found the last-named in rats and, as larvae, in cockroaches *(Periplaneta americana)* in the London Zoological Gardens. Material from bisected cockroaches was fed, one half to laboratory bred rats, and the other half to lambs, both groups of animals becoming infected, but the measurements of the adult worms were those of *G. neoplasticum*. He stated that, though his parasite could under experimental conditions be developed in sheep, in that abnormal host is retained the morphology characteristic of it in its normal host, and consequently was not a synonym of *G. scutatum*.

Leiper's criticism was replied to by Sambon (1926, 314) and by Baylis (1926, 503) who maintained their previous views as to the identity of *G. pulchrum* and *G. scutatum*, though *G. neoplasticum* was admitted to differ in one particular feature. Leiper (1926, 504) gave a further reply, maintaining that the three were distinct species.

Baylis, Sheather and Andrews (1926, 194) carried out investigations regarding the life history, using dung beetles, the cockroach *(Blattella germanica)*, and *Gongylonema* from cattle. They were able to transmit it to cattle and to sheep but not to pigs, but no morphological differences between worms from pigs and from ruminants could be detected. Adult worms were found in a calf and in sheep twenty weeks after infection. The same authors a little later (1926, 346) announced that they had succeeded in infecting pigs by using *Blattella germanica* and *Gongylonema* derived from cattle. *G. ransomi*, described by Chapin from American pigs, was added to the synonymy. It was stated that perhaps pigs and human beings were only accidental hosts of the species which normally inhabited the mucosa of the oesophagus of ruminants, whereas in the other hosts it occurred in the mucosa of the mouth and tongue rather than the oesophagus. Infective larvae were found to emerge spontaneously from their insect intermediate hosts when the latter were killed and placed in water. Since they are able to live some days in water, the latter must be regarded as a possible source through which final hosts may become infected. Blair (1926, 297) referred to the rupture of the cyst wall enclosing the larva when in contact with water, thus permitting escape.

Stiles and Baker (1927, 67) were able to transfer *G. scutatum* of cattle to white rats *(Rattus norvegicus albus)* through *Blattella germanica*, there being a light infestation in the oesophagus of only a few of the experimental rodents, and no trace of cancer such as is found associated with the rat parasite, *G. neoplasticum*, was caused.

Schwartz and Lucker (1931, 46) utilized worms from sheep, infected cockroaches and then succeeded in infecting pigs. Lucker (1932, 135) found that 106 days were necessary for Gongylonema to reach maturity in the pig, the eggs having been derived from sheep and cattle, and the larval stages passed through cockroaches. The period required was much greater than that reported by Baylis,

Pane and Sambon (1925) for ruminant *Gongylonema* to attain maturity in rats. Lucker re-examined Chapin's material of *G. ransomi* and confirmed Baylis' opinion (1925, 75) that it, together with *G. scutatum,* was a synonym of *G. pulchrum.* Mature specimens of ruminant origin, developed experimentally in white rats, guinea pigs and rabbits, were found to be indistinguishable from *G. pulchrum,* which was fairly common in pigs in U.S.A. Alicata (1934, 51), published some observations on the development to maturity in the guinea pig.

*G. pulchrum* in its structure and life history closely resembles *G. neoplasticum,* which appears to be a distinct species infesting rats and mice. The latter was first known from Denmark and the Danish West Indies (Fibiger, 1913; Fibiger and Ditlevsen 1914) and has been found subsequently in Holland and Surinam by Wassink (1916, 1,108) and Baylis (1925, 316); in London by Leiper (1926); in Formosa (var. *orientale)* by Yokogawa (1925); in U.S.A. by Lucker (1931); and in Russian Asia by Sassuchin, Tiflow and Schulz (1935, 656). Its larval stages can be passed in the cockroaches *Blatta orientalis, Periplaneta americana* and *Ectobia* (or *Blattella) germanica,* as well as in the meal worm, *Tenebrio molitor.* Yokogawa (1925) reported that the larvae of *G. orientale* occurred in the muscles of *Periplaneta americana* and *P. australasiae. G. neoplasticum* and *G. orientale* differ from *G. pulchrum* in their pathological effects, as they may give rise to neoplasms, Fibiger (1913; 1920), Wassink (1916) and Yokogawa (1925) having paid particular attention to this subject.

Hall (1924, 122-3) mentioned the use in meat inspection of pigs in U.S.A. of a scratching apparatus consisting of a wooden skewer from the conical end of which a bent pin projected less than one-quarter inch. The instrument is pulled across the tongue to make a series of shallow furrows in the dorsal mucosa between the papillae at the root of the organ and a line drawn across it, two or three inches in front of the vallate papillae. Worms, if present, are pulled out and recognised. Lucker stated that examination for the presence of this parasite in pigs' tongues is now part of the routine of meat inspection in U.S.A.

Sambon published figures showing abundance of the worms *in situ* in the oesophagus of Italian sheep (1925, 71) and cattle (1926, 257).

Railliet (1893, 541) suggested that *G. scutatum* might be a synonym of *G. pulchrum,* and Neumann recognised the close relationship between the two. The latter author (1894) attributed a very imperfectly known form, *Spiroptera ursi* Duj 1845, to the genus, and this together with some of Molin's species *(filiforme* and *spirale)* was subsequently considered by Baylis (1925) as probable synonyms of *G. pulchrum.* It should be remarked that the three species of Molin described in 1857, and just referred to, have page precedence as follows:—*G. filiforme* (p. 220), *spirale* (p. 222) and *pulchrum* (p. 223); hence if they are synonyms, *G. filiforme* has precedence. *G. spirale* was obtained from a deer, *Cervus dama,* and is probably synonymous with *G. pulchrum. G. filiforme* will be referred to later.

Baylis (1925) considered that *G. ursi* (Duj.) was a probable synonym. This species, described by Dujardin (1845) as a *Spiroptera,* was a renaming of *Sp. ursi-arcti* Rudolphi (1819, 253). The latter author referred to it also as *Sp. ursi* and *Strongylus ursi* (p. 28) and placed it amongst the doubtful species. His brief account is based on that of Bremser who examined four worms 12-14 lines long from the oesophagus of a brown bear, not a polar bear as stated in several parasitological articles. Stiles and Hassall, in the Index Catalogue (1926), indicate that Rudolphi's name was based on *Taenia ursi* Gmelin 1790, and was attributed by him in 1809 to *Strongylus,* Diesing in 1851 transferring it to *Nematoideum.* It seems obvious that the parasite is quite unrecognisable and the name had best be treated as a nomen nudum, otherwise the name *ursi* must take precedence over all the others associated with *G. pulchrum,* if they are synonym-

ous. Sambon (1925, 315) also referred to *G. ursi.*[1] In 1860 Molin described *contortum* from the same host species, *Ursus arctos*, Cobbold (1879, 297) calling it *Spiroptera (Gongylonema) contorta*. In 1894 Neumann (1894, 473) regarded it as a synonym of *G. ursi* which he transferred to *Gongylonema*, and this opinion was supported by Stossich (1897, 133), but the latter retained Molin's name. Faust (1930, 421) accepted *G. ursi* as a synonym of *G. pulchrum*. Baylis (1929) and Sprehn (1932) did not refer to *G. ursi* in their lists of synonyms.

*G. confusum* Sonsino (1896) from a horse in Egypt, was regarded by Seurat (1916, 726) as synonymous with *pulchrum*, and this opinion is accepted by later authors.

*G. pulchrum* of Seurat (1912, 1914—not 1916) from a hedgehog in Algeria, is a distinct species, subsequently described by that author (1916) as *G. mucronatum*.

The following is a list of the synonyms of *G. pulchrum* Molin 1857:—*Spiroptera scutata oesophagea bovis* Müller, 1869; *Filaria scutata* Leuckart, 1873; *Spiroptera scutata; Gongylonema scutata* Railliet, 1892; *G. confusum* Sonsino, 1896; *G. ransomi* Chapin, 1922; *Filaria labialis* Pane, 1864; *Agamofilaria labialis* Castellani and Chalmers, 1913; *G. labiale* Yorke and Maplestone, 1926; *G. subtile* Alessandrini, 1914; *G. hominis* Stiles, 1921; *Myzomimus scutatus* Stiles, 1892.

The following may perhaps be synonymous with *G. pulchrum*:—*Strongylus ursi* Rud., 1809; *Spiroptera ursi* Rud., 1819; *G. contortum* Molin, 1860; *Spiroptera contorta* Cobbold, 1879; *Spiroptera ursi-arcti* Rud., 1819; *Spiroptera ursi* Duj., 1845; *G. filiforme* Molin, 1857 (in part), and other species from monkeys, referred to later; and *G. spirale* Molin, 1857. The last-named was taken from a deer and, since undoubted specimens of *G. pulchrum* have been recognised from other deer by Baylis (1925) and Lucker (1933), Baylis was most probably correct in adding it to the synonymy, but the name has page priority over *G. pulchrum*.

The parasite is known from a wide range of hosts, though it occurs more commonly in the domestic ruminants, especially sheep and cattle. To this list are to be added goats, zebu, and buffalo; as well as the deer, *Dama dama* (by Molin, 1857); chevrotain, *Tragulus* sp. (by Baylis, 1925); and mule deer *Odocoileus hemionis* (by Lucker, 1933, 249). The pig not uncommonly serves as a host, and the parasite has been reported from the wild boar. Occasional hosts are man, certain monkeys, horse, ass and dromedary. Baylis and Daubney (1923, 569) reported it from the ox; *Bos bubalus;* and the Karkar sheep or urial, *Ovis vigneri*, from India. Perhaps the brown bear may serve as a host.

It has been carried through to maturity (by experimental infections with larvae) in the rat *(Epimys norvegicus albus)*, rabbit and guinea pig.

The larval stages are passed through in various species of dung beetles belonging to the genera *Onthophagus*, *Aphodius*, *Caccobius* and *Oniticellus*, as well as in the cockroach, *Blattella germanica*.

*G. pulchrum* is now known from various European localities, having been reported more frequently from the warmer southern portions, more particularly Italy and France (Railliet; Neumann). Alessandrini (1908), Sambon (1925, 66; 1926), Baylis (1925, 71) and Sebastiano (1926) referred to its abundance in Italian sheep and cattle. Raffaeli (1925) reported it as occurring in 20% of oxen, 70% of sheep and 0·3% of pigs slaughtered at Ravenna. Baylis (1925, 73) mentioned its presence in domesticated buffaloes in Italy. Sambon (1925, 316) reported it from oxen in Holland.

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[1] It is of interest to note that Inukai and Yamashita (Trans. Sapporo Nat. Hist. Soc., vol. xiii, 1934, p. 324-5) have recorded the occurrence in the Japanese variety of the brown bear, *Ursus arctos yesoensis*, of a nematode, *Ascaris lumbricoides*, whose common hosts are human beings and pigs.

It has been recorded by several observers from the United States:—Stiles (1892), Ransom (1911), Hall (1924), Chapin (1922), Lucker (1932), and others. Other localities are India, China (Schwartz, 1926) and Victoria (Sweet, 1909). Additional Australian localities are mentioned at the end of this paper.

The species of *Gongylonema* from primates other than man may be referred to. Seurat (1916) mentioned *Macacus sinicus* and *M. sylvanus (i.e., inuus)* as hosts. Lucker (1933, 248) recorded it from the spider monkeys *Ateles* sp. and *Cebus capucinus.* Stiles, Hassall and Nolan (1929, 468), in their catalogue of parasites reported for primates, mentioned two species of *Gongylonema, viz.: G. pulchrum* from man and the two monkeys *Macacus sylvanus (inuus)* and *Silenus sinicus;* and *G. filiforme* from the former. The latter parasite was named by Molin (1857) to replace *Filaria gracilis simiae-inui,* but Linstow (1899) Stossich (1897), as well as Yorke and Maplestone (1926), regarded it as a synonym of *Dipetalonema gracile* Dies. Baylis (1925) suggested that it was a synonym of *G. pulchrum.* Van Thiel (1925) considered it a valid species of *Gongylonema,* as also did Lucker (1933, 248), the latter stating that the only host now definitely known to harbour *G. filiforme,* was *Macacus inuus.* Lubimov (1931, 446) reported a new species, *G. macrogubernaculum,* from the oesophagus or bronchi of three monkeys, *Macacus rhesus, Cebus hypoleucus,* and *Cercopithecus tamapsin* (? = talapoin) from the Zoological Park, Moscow; Lucker (1933, 243) recording it from *Macacus lasiotis* and *Papio rhodesiae,* both from Zoological Gardens in U.S.A. Gebauer (1933, 730) described *G. microgubernaculum* from the oesophagus and bronchi of *Silenus rhesus.* In view of the known variability of *G. pulchrum* and its capability to parasitise primates, as well as the fact that dung beetles and cockroaches serve as its intermediate host and would have access to infective material from ruminants, etc., housed in zoological gardens and could be eaten by monkeys lodged there, it is suggested that these species, especially *G. macrogubernaculum* and *G. microgubernaculum,* may be synonyms of *G. pulchrum.* Van Thiel (1925, 176) described a nematode, *Squamanema bonnei* from a South American monkey *Alouatta seniculus,* which he placed in the Gongyloneminae, but Yorke and Maplestone (1926, 315), as well as Baylis and Daubney (1926, 212), considered the genus as close to *Parabronema,* which is placed in a different subfamily of the Spiruridae, while Chitwood and Wehr (1934, 319) regarded it as a synonym of *Parabronema* (Habronematinae). In his account of *G. saimirisi* from a Brazilian monkey, Artigas (1933) discussed the possibility of it becoming a human parasite.

Three species of Gongylonema have been recorded as occurring in Australia, viz.: *G. scutatum* by Sweet (1909, 523) from a cow in Victoria; *G. ingluvicola* Ransom by Johnston (1918, 215) from the proventriculus of a fowl in Sydney, and *Gongylonema* sp. by Johnston (1918, 61) from the liver of a mouse and of a white rat in Sydney.

*G. pulchrum* (syn. *G. scutatum)* occurs occasionally in cattle in Queensland, and I have seen specimens from the same host from Sydney and Adelaide abattoirs. It has not yet been identified from sheep, pigs or goats in Australia. Kauzal (1930) makes no reference to it in his list of parasites known to occur in pigs in New South Wales, nor does Roberts (1934) in his list of those reported from domesticated animals in Queensland. *G. ingluvicola* occurs in North Queensland, as I have received material taken from chickens in Mackay. *Gongylonema* sp. from rodents was probably *G. neoplasticum.*

Cleland (1918, 119-120), in referring to the carcinogenic effects attributed to the latter species, suggested that in a case of very heavy infestation of the stomach of a rat, *Epimys norvegicus,* in Western Australia, by nematodes recorded by him in 1912 as *Protospirura muris,* the parasite may perhaps have been *G. neoplasticum,* since pathological changes were present in the stomach wall.

He stated that sections of the stomach of an apparently normal rat revealed portions of a nematode embedded in keratinised squamous epithelium. The worms taken from the lumen were examined by me and were undoubtedly *P. muris,* while those represented in the sections were probably *Gongylonema,* though *Capillaria* (or *Hepaticola) gastrica* Baylis is a possibility, Bonne, in 1926, having described a cancerous condition of the gastric mucosa associated with that species in the rat.

## Summary.

A review is made of the occurrence of *Gongylonema pulchrum* in man and various other animals, its life history, synonymy and distribution. Records of the occurrence of the genus in Australia are given.

Acknowledgment is made of the assistance derived from Stiles and Hassall's Index Catalogue, Nematode (1926).

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# CLIMATE IN RELATION TO INSECT ECOLOGY IN AUSTRALIA.
# 3. BIOCLIMATIC ZONES IN AUSTRALIA.

*BY J. DAVIDSON, D.SC.*

**Summary**

The insect fauna of an area is largely determined by the nature of the physical environment, in which temperature and moisture are dominating factors. Fluctuations in the numbers of insects and the intensity of their activities are largely determined by temporary or seasonal weather changes; biotic factors, such as food and competition, are important additional considerations.

# CLIMATE IN RELATION TO INSECT ECOLOGY IN AUSTRALIA.

## 3. BIOCLIMATIC ZONES IN AUSTRALIA.

By J. Davidson, D.Sc.
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With large coloured Map of Australia.

[Read May 11, 1936.]

The insect fauna of an area is largely determined by the nature of the physical environment, in which temperature and moisture are dominating factors. Fluctuations in the numbers of insects and the intensity of their activities are largely determined by temporary or seasonal weather changes; biotic factors, such as food and competition, are important additional considerations.

The distribution in Australia, month by month, of the chief elements of climate affecting temperature and moisture in the environment of insects was discussed in parts 1 and 2 of this paper (Davidson, 1934a, 1935). With the aid of this earlier information, which was presented in the form of monthly charts, the writer mapped Australia into areas, in which the average moisture and temperature "conditions" are known. By means of suitable combinations of these areas, various zones have now been defined, which are referred to as Bioclimatic zones; they are shown on the map of Australia presented here. From the aspect of insect ecology, these Bioclimatic zones are areas in which the essential elements of climate, affecting the physical environment of insects, have been assessed, so that comparisons may be made of the insect fauna in zones having similar or different environments. Apart from edaphic factors, temperature and moisture largely determine the distribution of vegetation types, with which insect life is intimately associated. Therefore, from the broader aspect of ecology, the term Bioclimatic zone embraces the elements of climate and natural features which characterise a zone, and determine life responses within the zone. The term was used by Hopkins (1921), who states ". . . . It is to temperature that we must look for the most reliable guide to the preliminary interpretation of the distribution and range of the zones . . ." Although temperature has been widely used as an index to the distribution and seasonal activity of insects, ecological studies during the past 15 years or so have abundantly demonstrated the importance of moisture, and shown that temperature alone cannot be considered as an adequate climatic index for this purpose.[1]

### Moisture Zones.

Rainfall and atmospheric humidity are the chief climatic elements which determine the moisture available in the environment of insects. Species differ in their moisture requirements and resistance to dryness; those best suited to an arid environment appear to have low water requirements or to resist the loss of body water. In dry regions, moisture restricts or limits the permanent establishment of insects, and in those areas having a definite dry season their activities may be restricted to the favourable months of the year (wet season); the insects survive the dry months by aestivation in particular stages of their development. Owing to the mild climate and marked seasonal rainfall in Australia, moisture is to be considered as the major influence affecting the distribution and seasonal activity of insects in the continent. The significance of the mean monthly Pre-

[1] See R. N. Chapman, 1931, Animal Ecology, chapter 10: B.P. Uvarov, 1931, Insects and Climate, Trans. Entom. Soc., London, **vol. lxxix.**

cipitation -Evaporation ratio, referred to as P/E, as an index to moisture "conditions" in the environment of insects, has been discussed in the earlier papers. By means of this ratio, the intensity of wetness or dryness in any month may be classified according to the following values for P/E.

| Values for P/E. | Degree of Wetness or Dryness. |
|---|---|
| $>4$ | wet |
| 2—4 | humid |
| 0·5—2 | semi-humid |
| 0·25—0·5 | semi-arid |
| $>0{\cdot}25$ | arid |

For the purpose of mapping moisture zones in Australia, P/E = 0·5 has been selected as the value below which adequate moisture will not be available for general plant growth at the soil surface, and in the upper layers of the soil. Under Australian conditions, the months in which P/E has a value of 0·5 or over may be considered as the "growing period"; those months in which P/E is less than 0·5 may be considered as the "dormant period." Owing to accumulation of moisture in the soil at the end of the growing period, moisture will be effective, for a time, after the value of P/E falls below 0·5. The length of this period will depend upon the P/E ratio together with soil type and vegetation. Temperature and the value of P/E will be the dominating factors affecting the growth and activity of plants and animals during the growing period. In the dormant months, temperature and atmospheric saturation deficit will be the important factors associated with P/E, determining the intensity of desiccation. The areas in Australia, month by month, in which P/E = 0·5 or over, are defined in the earlier paper (Davidson, 1935). By superimposing the twelve monthly charts, a composite chart of Australia was prepared, showing the months and approximate areas in which P/E = 0·5 or over (fig. 1). It was not practicable to illustrate, separately, on the map presented with the present paper, the areas for individual months, so areas were defined showing the number of months in the year in which P/E is 0·5 or over. For those months included in the period November to April, the areas are shown in colours; by this means the regions in which summer rainfall is effective are clearly defined. In the case of the months included in the period May to October, the areas are shown by hatching lines; in this way the regions in which winter rainfall is effective are clearly defined. The total number of months of the year in which P/E = 0·5 or over, for any area, is obtained by adding together the months for both periods.[2] The degree of wetness or dryness in any area, month by month, depends upon the duration of particular values of P/E. Those areas having a run of one to six months in which P/E = 0·5 or over are classified in the *arid zone,* and those having a run of seven to twelve months in the *humid zone.* The subdivisions of these zones are given in the key at the top right-hand corner of the map. When considering the classification of an area, it is necessary to note the number of *consecutive* months in the year in which P/E = 0·5 or over. Over the northern portion of Australia, the months during which P/E = 0·5 or over lie in the period November to April. In the southern portion they lie in the period May to October; with some areas they

[2] The months and approximate areas in which values for P/E lie between 0·5 and 0·25 were also defined, but this information has not been included in the map. These low values for P/E are important in relation to the subdivision of the arid central portion of Australia. It is considered inadvisable at present, however, to use values for P/E less than 0·5 for this purpose, because of the inadequate meteorological data available for this region. Moreover, high values for atmospheric saturation deficit, particularly during the summer months, and the prevalence of hot winds render the computed values for evaporation liable to considerable error.

extend into the period November to April (fig. 1). In the eastern portion of the continent the demarcation of the monthly areas is complicated by overlapping of effective summer and winter rainfall, and in certain parts of this region, the

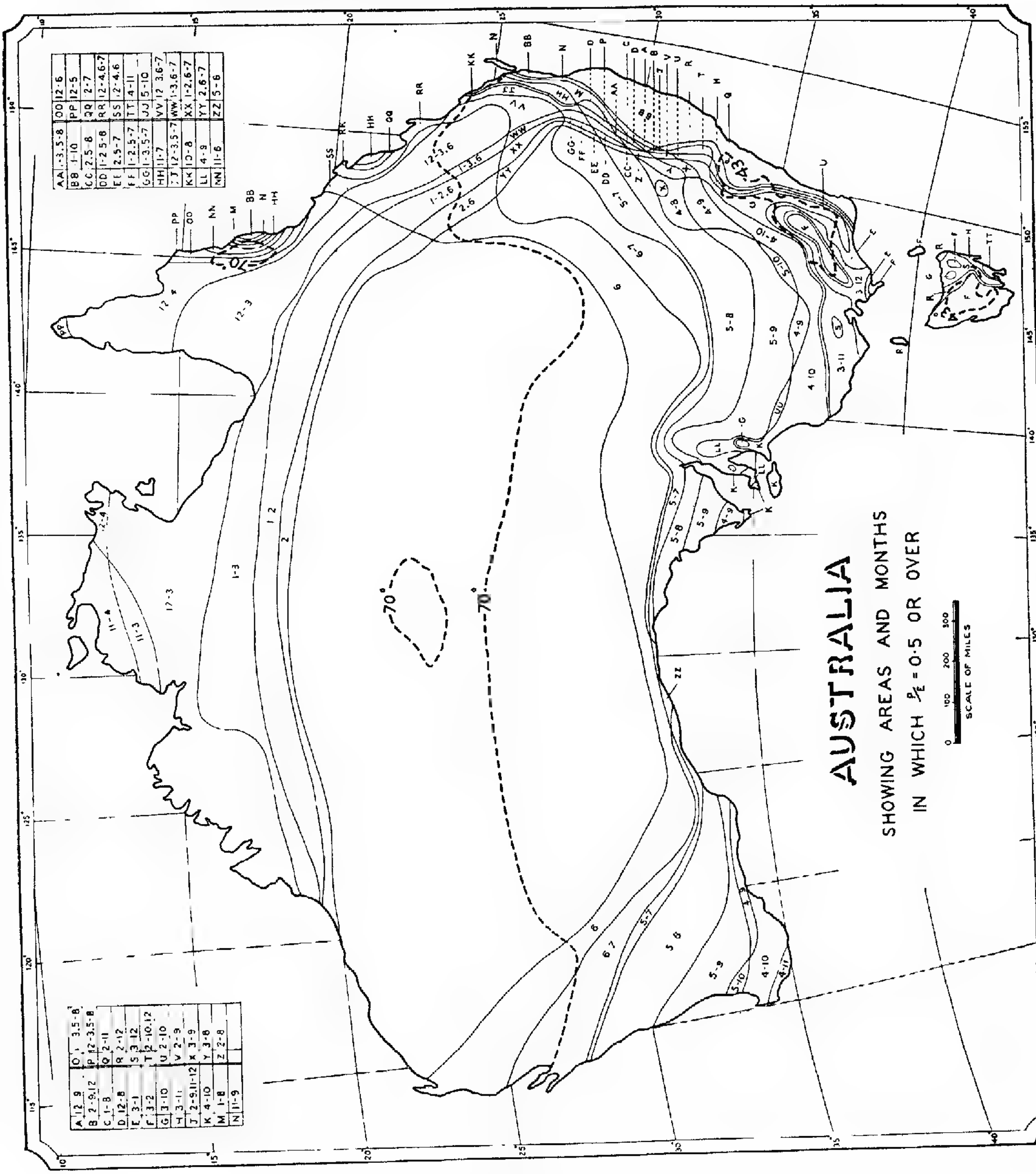


Fig. 1.

In the areas defined on the chart, the months are given in which values for P/E are 0·5 or over. These months are designated by letters or by appropriate numbers, *e.g.*, VV = December to March, June and July; 12-3 = December to March. The broken lines are isopleths of *(a)* mean annual temperature 70°F., *(b)* mean temperature 43°F. for the coldest month (July); these lines form the boundaries between *(a)* hot and warm temperate climates, *(b)* warm temperate and cool temperate climates as stated in the text.

months in which $P/E = 0 \cdot 5$ or over do not run on consecutively (fig. 1). Where the intervening period, during which $P/E$ is less than $0 \cdot 5$, is one month only, adequate moisture will be available for that month, and it can be included in forming a consecutive run of months in which $P/E = 0 \cdot 5$ or over. Where the period is longer than one month, it is to be considered as a dry period; the intensity of the dryness will depend upon the value of $P/E$ and the duration of the period. It is seen from fig. 1 that the area in which $P/E = 0 \cdot 5$ or over during June, extends well into Queensland; to a less extent, this is also the case with July. This extension, during the winter months, into a definitely summer rainfall zone, is due to the effect of low temperatures in reducing evaporation.

The extremes of aridity will be in those areas having low values for $P/E$ maintained for long periods. The values may be infinitely small if no rain falls; when rain does fall, it may have no biological significance owing to being insufficient to penetrate the soil, or to the rapid loss of moisture in the dry soil and by evaporation.(3) The term desert is used in this paper in an ecological sense, to include the arid central regions of Australia, in which the values for $P/E$ are below $0 \cdot 5$ for every month of the year. The vegetation is characterised by climax associations of the semi-desert and desert type (Prescott, 1931). The percentage rain reliability over the greater part of this region lies between 35-40 (Andrews, 1932). Seasons occur with adequate rains, when ephemeral vegetation and certain insects may be temporarily abundant; the intervening drought periods may be prolonged for several seasons.

The extremes of wetness will be in those areas having high values for $P/E$ maintained for long periods. The number of consecutive months in which $P/E$ is greater than unity is a general guide to the degree of wetness in an area (Davidson, 1934). A more detailed classification can be developed by taking into account the duration of the following values for $P/E$:—

0·5—2 (semi-humid), 2—4 (humid), over 4 (wet).

## Temperature Zones.

The range of temperature favourable for insects varies with the species. Low temperatures restrict or limit the distribution of insects polewards or in altitude. Outside the equatorial belt, the seasonal march of temperature may restrict or limit insect activity to the warmer months of the year. Species inhabit-

(3) The minimum amount of rain, in one fall, necessary to ensure that moisture in the soil may be biologically effective, will vary according to circumstances. Apart from soil type and its vegetation covering, it will depend upon the requirements of the particular plants and animals in the area. Also, it will depend upon whether the fall occurs during a definite rainy period (growing period referred to in the text), or during a drought period (dormant period referred to in the text). The amount of rain required will be less during a rainy period than during a dry one; in the former, moisture accumulates in the soil; during a dry period the rain must not only penetrate into the soil, but adequate moisture must be retained for the requirements of the organisms.

With heavy falls of rain, there is an unavoidable waste by "run-off" water going to local situations. The minimum amount of rain, in one fall, which will bring this about depends upon the slope, soil type and vegetation, and the amount of rain in relation to the duration of the fall.

Müsson, C. T. (Agric. Gazette, N.S. Wales, 1904, vol. xv, p. 781), in dealing with variations in rainfall at Hawkesbury Agricultural College, Richmond, New South Wales, states that only rains amounting to 0·20 inches do real good in an agricultural way. Cannon, W. A. (Carnegie Institution, Washington, 1921, Pubn. 308, p. 48), from observations made in the dry north of South Australia, defines an ecologically effective rainfall as one consisting of 0·15 inches or more and which falls during a distinct rainy period. Osborn, T. G. B.; Wood, J. G.; and Paltridge, T. G. B. (Proc. Linnean Soc. N.S. Wales, 1936, vol. lvi, p. 302), from observations made at Koonamore in the dry north of South Australia, consider "that about 0·25 inches is nearer the minimum amount of rain that is effective during a dry period; lighter falls do not penetrate the soil more than 2-3 cm."

ing these regions survive the cold months by hibernation in particular stages of development.

Temperature has long been used as a basis for the classification of climates. Miller (1931, p. 53) discusses the question and has prepared a table showing the approximate boundaries of different climates based on temperature. The first three climatic zones adoped by Miller are:—

A. *Hot climates*—Mean annual temperature above 70° F.

B. *Warm temperate*—No month with mean temperature below 43° F.

C. *Cool temperate*—One to six months with mean temperature below 43° F.

The climates of Australia lie in the Zones A and B, with the exception of elevated portions of the Australian Alps in Victoria and southern New South Wales, and the western highlands of Tasmania; these latter areas fall into Zone C (fig. 1).

The distribution over Australia of mean annual temperatures, at intervals of 5° F., is shown on the map. The key to the temperature zones adopted is given in the top right-hand corner of the map. The isopleth for the mean annual temperature 50° F. has been adopted as the boundary of the cool temperate and warm temperate zones, but in many respects the isopleth for 55° F. could very well be taken as the boundary (compare the area enclosed by the isopleth 43° F. for the coldest month in Fig. 1).

From an ecological point of view, mean annual temperatures have little value; they are adequate in this instance for defining the broad temperature zones, since moisture is the dominating factor. By reference to the charts showing the distribution of mean monthly temperatures (Davidson, 1935), the mean temperatures, month by month, may be defined for the various moisture zones.

C. W. Thornthwaite (1933) employed the term *"temperature efficiency"* in association with that of *"precipitation effectiveness,"* for the purpose of the delimitation of the boundaries of "The Climates of the Earth." The methods whereby numerical values for these concepts were calculated is described in an earlier paper (Thornthwaite, 1931). With regard to temperature efficiency, the following equation was developed by empirical means, from which monthly indices were obtained:—

$$\frac{\text{Monthly Temp. °F.} - 32\text{°F.}}{4}$$

By means of appropriate values for summations of monthly indices, six temperature zones were defined. With regard to precipitation effectiveness, values for this concept were calculated by means of a formula which has been discussed by Prescott (1934).

It is of interest to compare the boundaries of the climatic types in Australia given by Thornthwaite (1933) with those developed by the writer in the present paper.

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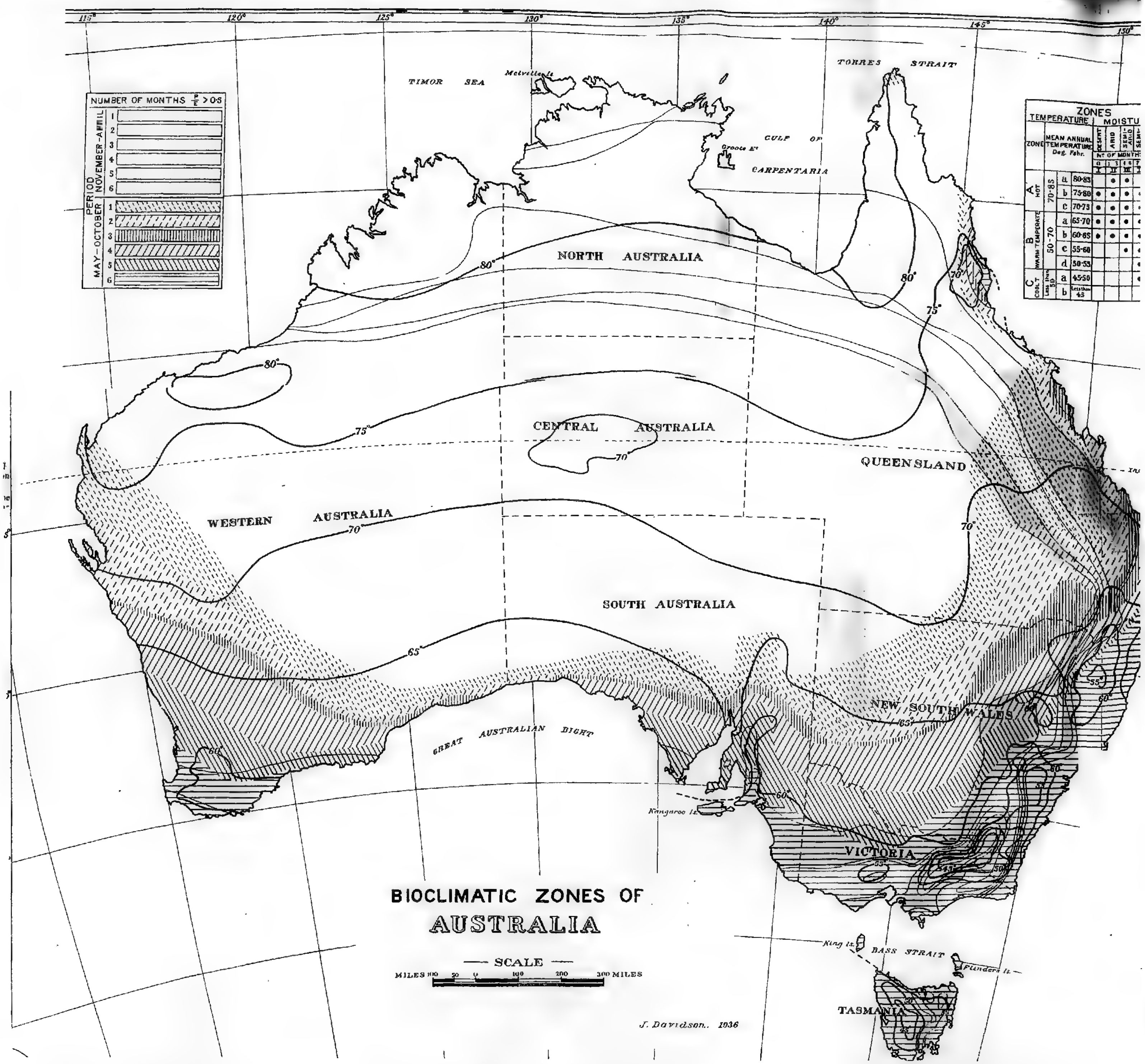

NUMBER OF MONTHS P/E > 0·5
PERIOD
NOVEMBER-APRIL
MAY-OCTOBER
ZONES
TEMPERATURE
MOISTU
MEAN ANNUAL TEMPERATURE Deg. Fahr.
A HOT 70-85
B WARM TEMPERATE 50-70
C COOL Less than 50
TIMOR SEA
Melville Is.
TORRES STRAIT
GULF OF CARPENTARIA
Groote E.
NORTH AUSTRALIA
CENTRAL AUSTRALIA
WESTERN AUSTRALIA
SOUTH AUSTRALIA
QUEENSLAND
NEW SOUTH WALES
VICTORIA
TASMANIA
GREAT AUSTRALIAN BIGHT
Kangaroo Is.
King Is.
BASS STRAIT
Flinders Is.
BIOCLIMATIC ZONES OF
AUSTRALIA
SCALE
MILES 100 50 0 100 200 300 MILES
J. Davidson. 1936

# THE CLIMATIC CONTROL OF THE AUSTRALIAN DESERTS

*BY J. A. PRESCOTT, D.SC.*

**Summary**

In a previous paper (1934) the usefulness of monthly climatic factors combining rainfall with some function of evaporation was pointed out, and Davidson (1936) has subsequently developed his previous work on this subject in the subdivision of Australia into bioclimatic zones based on a critical ratio of rainfall to evaporation of 0-5 for any given month. Andrews and Maze (1933) have already discussed aridity in Australia, using the de Martonne relationship of rainfall to temperature for this purpose. For various reasons, previously outlined, the most suitable relationship is one which combines rainfall with the saturation deficit of atmospheric humidity; the ratio of precipitation to this deficit is probably the most efficient for the purpose, having been first suggested as an annual ratio by Meyer, after whom it is usually named.

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By J. A. Prescott, D.Sc.,
Waite Agricultural Research Institute, University of Adelaide.

[Read August 13, 1936.]

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As a test of the efficiency of the successive monthly values, this ratio has been calculated month by month for the more arid regions of Australia, and lines drawn representing the values below which the ratio does not fall in any of the twelve months of the year. For no part of Australia does the ratio fall below 1 for all twelve months, but there is an appreciable area in which these values never rise above 2. This area coincides with the heart of the Arunta or Simpson Desert, which is suspected from the lack of aboriginal occupation and from the difficulty of penetration, to be the most arid part of the continent. Lines have been drawn for the values 3, 4, 5 and 6, and the greater part of the truly desert region is seen to fall within the area circumscribed by the lines representing twelve months with values of less than 4 or 5.

On the same map (fig. 1) have been projected the areas covered by sand ridges, as recently delineated by Madigan (1936).

The significance of these values is evident from a consideration of soil moisture relationships; a value of 5 corresponds roughly with a precipitation-evaporation ratio of 0·3 allowing for evaporation from a large water surface such as a reservoir. At the Waite Institute, a ratio of 5 is sufficient to maintain the moisture content of the surface soil at about the wilting point.

Köppen (1923) has suggested that desert areas can be determined climatically by the following relationships:—

*(a)* for rain in the cool season, P is less than $\frac{1}{2}$ (t + 22),
*(b)* for uniform rain, P is less than $\frac{1}{2}$ (t + 33),
*(c)* for rain in the warm season, P is less than $\frac{1}{2}$ (t + 44),
where P is annual rainfall expressed in centimetres,
and t is the mean annual temperature in degrees centigrade.

The limits imposed by the above relationships have, therefore, also been depicted on the map.

A consideration of three methods of approach, use of the 10-inch isohyet, the Köppen formulae and the use of monthly values of P/s.d., indicates successive turns in the axis of aridity in a clockwise direction. There is a suggestion in the map that a further turn in this direction is required to bring the axis into con-

formity with that of the existing zone. Szymkiewicz (1925) has suggested the substitution of the value s.d. $\times \dfrac{273 + T}{273}$ for saturation deficiency, a factor which takes into account the greater diffusivity of water vapour at the higher temperatures. The monthly ratios of precipitation to this new measure of evaporation have, therefore, been calculated, but without any appreciable change in the general features of the map or in the alignment of the axis. The most important

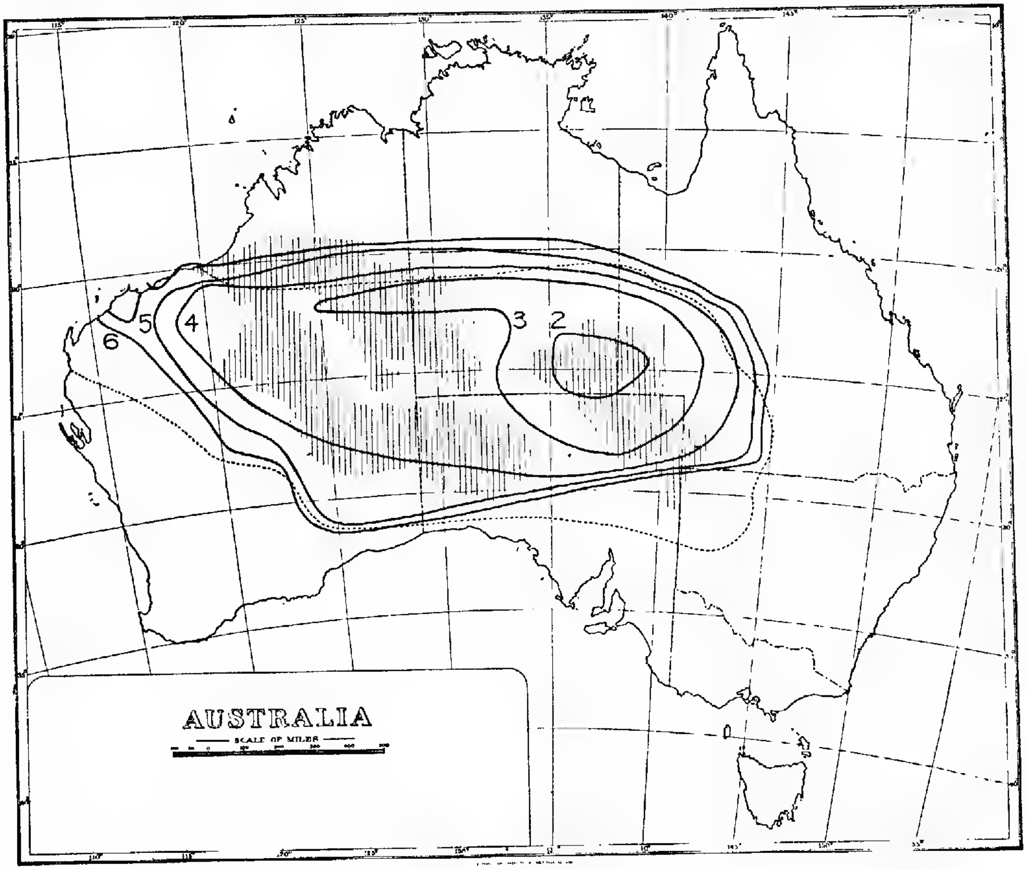


Fig. 1

Showing the zones for which the monthly ratios of precipitation to saturation deficit are less than the values indicated for every month of the year. The broken line indicates the limits of desert climate calculated according to Köppen's formulae.

The shading indicates the extent of desert sandhills according to Madigan.

remaining feature omitted from consideration is the effect of wind, which, as the south-east trade wind, plays a very important part in the northern half of this arid region. This would, undoubtedly, tend to extend the climatic zone towards the north-west.

## Conclusions.

A satisfactory estimate of the aridity of the Australian climate can be obtained by a consideration of the monthly values for the ratios of precipitation

to the saturation deficit of water vapour pressure. Where these values do not exceed 4 or 5 for any of the twelve months of the year, the soil moisture throughout the year is maintained below the wilting point of plants except immediately after rain for short periods or in special habitats, so that desert conditions may be expected. A close relationship between these values and the known distribution of sandy deserts is to be observed. A small portion of Australia, near the borders of Central Australia, Queensland and South Australia, shows values of 2 or less for each of the twelve months. This area has long been suspected from other considerations to be the most arid in Australia.

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# REGENERATION OF THE VEGETATION ON THE KOONAMORE VEGETATION RESERVE, 1926 TO 1936.

*BY J. G. WOOD, PH.D., D.SC.*

**Summary**

In a previous paper (2) an account was presented of the progress of work at the Koonamore Vegetation Reserve up to 1931, that is, after five years of enclosure. That paper dealt with the climatic data, the methods of study employed, general biological observations on arid plants and with the initial stages of regeneration of the perennial native plants.

# REGENERATION OF THE VEGETATION ON THE KOONAMORE VEGETATION RESERVE, 1926 TO 1936.

By J. G. Wood, Ph.D., D.Sc., Department of Botany, University of Adelaide.

Plates V to XIV.

[Read August 13, 1936.]

In a previous paper (2) an account was presented of the progress of work at the Koonamore Vegetation Reserve up to 1931, that is, after five years of enclosure. That paper dealt with the climatic data, the methods of study employed, general biological observations on arid plants and with the initial stages of regeneration of the perennial native plants.

The present paper describes quantitative measures of the regeneration of plants which has taken place within this area during a period of ten years. The data which have been acquired are especially valuable since they have been obtained during a period of prolonged drought, and give an insight into the drought resistance of the species concerned.

The Koonamore Vegetation Reserve, an area of 1,260 acres, situated in 32° 15′ S. lat., 139° 27′ E. long., was enclosed by a sheep- and rabbit-proof fence in July, 1925. Since that time no sheep or other stock have been inside the Reserve, although in 1931 rabbits reached plague numbers and extermination became necessary. About 7,000 rabbits were killed at the end of that year, but since then none have been present on the Reserve.

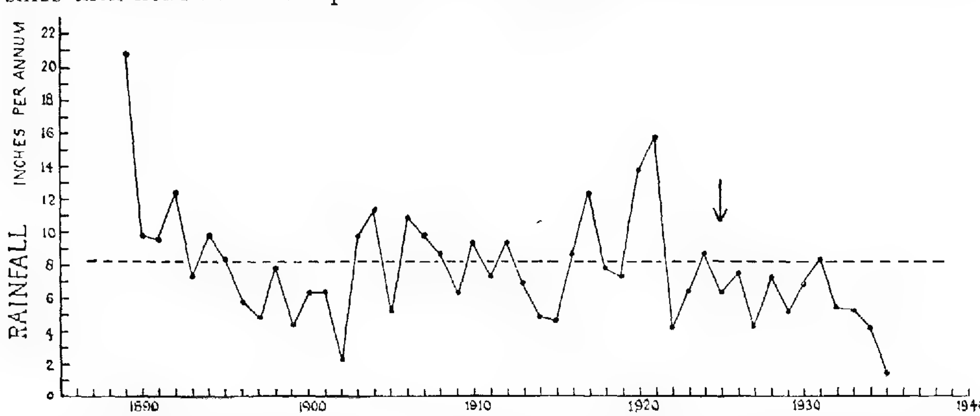


Fig. 1.

Graph showing annual rainfall at Koonamore from 1889 to 1936. The dotted line shows the mean annual rainfall. The Koonamore Vegetation Reserve was enclosed at the time indicated by the arrow. Note that since enclosure of the Reserve, the rainfall has been below the mean.

Permanent observations on the vegetation were commenced in June, 1926, utilizing the methods which have been described in the previous report, and these observations have been continued without interruption to the present time.

Since enclosure of the Reserve the North-East pastoral district, in which the Reserve is situated, has been subjected to prolonged drought conditions, which have exceeded in their severity any previously experienced since the country was first colonised. In text fig. 1 is given a graph showing the annual rainfall at Koonamore in each year since 1889. The graph shows that wet years and drought years tend to occur in cycles, although the observations do not extend back far

enough to define these cycles. Since 1922, and including the whole period during which the Reserve has been enclosed, the annual rainfall has been below the mean value.

It has been pointed out previously *(loc. cit.)* that the annual rainfall has little significance in arid Australia since violent storms are common during which 3 inches or more may fall in 24 hours, or alternatively many small falls occur which do little more than wet the surface of the ground. Therefore, whilst the annual rainfall gives a rough guide, a more detailed analysis is necessary to understand the reaction of arid plants to rainfall. From extended observations we have decided that a fall of less than 25 points is not effective in times of drought, although smaller falls are effective following other rains. The monthly rainfall, the number of rainy days, and also the number of days in which 25 points or more fell are given in Table I.

TABLE I.

*Rainfall at Koonamore during the period 1925-1936, together with the number of rain days and falls greater than 25 points. Rain periods which had a marked effect upon the vegetation are shown in black type.*

| Year. | | Jan. | Feb. | Mar. | Apl. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1925 | Rainfall .... .... | 159 | 10 | 0 | 36 | 218 | 1 | 115 | 20 | 35 | 14 | 28 | 5 | 637 |
| | Rainy days .... | 3 | 1 | 0 | 2 | 9 | 1 | 6 | 2 | 1 | 1 | 2 | 1 | 29 |
| | Falls > 25 points | 2 | 0 | 0 | 1 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 9 |
| 1926 | Rainfall .... .... | 0 | 2 | 36 | **64** | **166** | **61** | **24** | **104** | **224** | 0 | 7 | 62 | 750 |
| | Rainy days .... | 0 | 1 | 2 | 3 | 6 | 3 | 6 | 8 | 6 | 0 | 1 | 4 | 40 |
| | Falls > 25 points | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 2 | 3 | 0 | 0 | 1 | 11 |
| 1927 | Rainfall . .... | 62 | 33 | 7 | 0 | 1 | 76 | 26 | 17 | 90 | 8 | 50 | 39 | 409 |
| | Rainy days .... | 4 | 2 | 1 | 0 | 2 | 5 | 5 | 1 | 5 | 4 | 4 | 3 | 36 |
| | Falls > 25 points | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 6 | 2 | 0 | 0 | 0 | 6 |
| 1928 | Rainfall .. .... | 1 | 390 | 40 | 0 | 27 | **108** | **103** | 6 | 28 | 0 | 0 | 0 | 703 |
| | Rainy days .... | 1 | 4 | 3 | 0 | 2 | 6 | 5 | 1 | 2 | 0 | 0 | 0 | 24 |
| | Falls > 25 points | 0 | 1 | 1 | 0 | 0 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 8 |
| 1929 | Rainfall .... .... | 0 | 0 | 15 | 18 | 0 | 9 | 12 | 26 | 62 | 0 | 35 | 327 | 504 |
| | Rainy days .. | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 0 | 3 | 3 | 13 |
| | Falls > 25 points | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 4 |
| 1930 | Rainfall .... .... | 7 | 93 | 0 | 80 | 33 | 0 | 80 | 47 | 90 | **112** | **38** | **108** | 688 |
| | Rainy days ... | 1 | 4 | 0 | 2 | 3 | 0 | 6 | 4 | 3 | 6 | 2 | 3 | 34 |
| | Falls > 25 points | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 2 | 1 | 3 | 12 |
| 1931 | Rainfall .... .... | 16 | 0 | 76 | **437** | **84** | **148** | **76** | 27 | 25 | 47 | 4 | 0 | 839 |
| | Rainy days .... | 1 | 0 | 3 | 3 | 11 | 9 | 4 | 2 | 2 | 3 | 3 | 2 | 43 |
| | Falls > 25 points | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 8 |
| 1932 | Rainfall .... .... | 0 | 86 | 29 | 42 | 151 | 33 | 21 | 50 | 71 | 18 | 36 | 0 | 537 |
| | Rainy days ... | 4 | 7 | 2 | 5 | 4 | 4 | 2 | 6 | 4 | 1 | 2 | 0 | 43 |
| | Falls > 25 points | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 5 |
| 1933 | Rainfall .... .... | 40 | 45 | 26 | 1 | 65 | 7 | 50 | 67 | 11 | 14 | **162** | 22 | 510 |
| | Rainy days ... | 2 | 1 | 1 | 1 | 1 | 3 | 6 | 6 | 2 | 1 | 3 | 4 | 31 |
| | Falls > 25 points | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 7 |
| 1934 | Rainfall ... ... | 0 | 42 | 34 | 3 | 0 | 10 | 71 | 9 | 7 | 55 | 177 | 0 | 408 |
| | Rainy days .... | 0 | 4 | 2 | 2 | 0 | 3 | 4 | 1 | 2 | 5 | 6 | 0 | 29 |
| | Falls > 25 points | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 5 |
| 1935 | Rainfall .... .... | 0 | 0 | 33 | 36 | 1 | 28 | 0 | 3 | 55 | 67 | 16 | 16 | 255 |
| | Rainy days ... | 0 | 0 | 2 | 5 | 1 | 3 | 0 | 3 | 4 | 3 | 2 | 1 | 24 |
| | Falls > 25 points | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 3 |
| 1936 | Rainfall .... .... | 196 | 15 | 10 | 0 | 91 | 29 | — | — | — | — | | | — |
| | Rainy days ... | 6 | 2 | 1 | 0 | 1 | 3 | — | — | — | — | — | — | — |
| | Falls > 25 points | 2 | 0 | 0 | 0 | 1 | 0 | — | | | | — | — | — |

Inspection of the table shows that on the average only between one-third and one-quarter of the total falls of rain are effective as far as the plants are concerned. Correlation with the vegetation brings out the fact that only five rainy periods have been effective. These periods are the winter rains of 1926, 1928 and 1931 and the summer rains of 1930 and 1933. It is noteworthy that heavy falls such as those of February, 1928, December, 1929, and April, 1931, when over 3 inches fell in 24 hours in each case, caused no response from the permanent vegetation and did little but scour the ground and cause a deterioration of the seed bed.

The vegetation of the Reserve consists of three main types: The saltbush communities on hard loams containing travertine limestone nodules; the mulga scrub on sandhills; and annual communities on watercourses and flooded flats. A fourth type is also present, namely, a black oak *(Casuarina lepidophloia)* community on sand plains. The latter community is not dealt with here, for it is a stable community, reproducing from root buds and only occasional shrubs or annuals are found beneath the trees. The soils of the three main types have already been described (2). These three soil and vegetation types are similar to practically the whole of the plains area of the North-East of South Australia.

## I—THE SALTBUSH COMMUNITY

The saltbush community on the Reserve presents a phase intermediate between the mallee and true shrub-steppe. The mallee in South Australia is defined fairly accurately between the 15-inch and 8-inch annual isohyets. Within it two well-marked regions occur. Between the 15- and 12-inch isohyets the dominants are eucalypt species, chiefly *E. oleosa* and *E. dumosa*, whilst the permanent undergrowth consists of sclerophyllous undershrubs. Between the 12- and 8-inch isohyets the eucalypt species, with the exception of *E. oleosa*, practically disappear. Their place is taken by the sandalwood *(Myoporum platycarpum)* and the sclerophyllous shrubs are replaced by chenopodiaceous species, especially saltbushes *(Atriplex vesicarium* and *A. stipitatum)* and the bluebush *(Kochia sedifolia)*. At about the 8-in isohyet the eucalypt species disappear entirely and a very open community containing scattered individuals of *Myoporum platycarpum* and a continuous cover of saltbushes takes its place. The bluebush *(Kochia sedifolia)* replaces the saltbushes where limestone comes close to the surface. With increasing aridity *Myoporum platycarpum* disappears and a pure shrub steppe of *Atriplex vesicarium* takes its place.

The latter phase is not present on the Reserve, although it occurs and has been studied in areas not far removed from the Reserve. The community under investigation at Koonamore is the *Myoporum-Atriplex* community, but from the point of view of regeneration of saltbush the results obtained in the study of this community apply equally to the true shrub-steppe.

The permanent members of this community are seven in number: a tree, *Myoporum platycarpum* (sandalwood), a shrub *Cassia Sturtii* (birdseye or kangaroo bush), the shrubs *Atriplex vesicarium* and *A. stipitatum* (bladder saltbush and mallee saltbush, respectively), and *Kochia sedifolia* (bluebush), and two short-lived perennial undershrubs, *Bassia patenticuspis* and *B. obliquicuspis*. After rains a wealth of annuals, especially members of the Compositae and Cruciferae and a short-lived perennial *Stipa nitida* (speargrass) occur, but these are drought-escaping rather than drought-resistant plants and are not permanent members of the community.

## Atriplex vesicarium (Bladder Saltbush).

### *(a) Chemical Structure and Anatomy.*

This species is the most important fodder bush in arid Australia, since it alone supplies a food reserve in time of drought. It is nutritious and drought resistant.

The following analysis shows the mean composition of the turgid leaves, the constituents being expressed as percentage of fresh weight:—

| | |
|---|---|
| Water | 90·0 |
| Respirable Carbohydrates | 1·5 |
| Protein | 2·5 |
| Crude Fibre | ·5 |
| Ash | 3·8 |
| Alkali Soluble Resins, etc. | 2·0 |
| Total | 100·3 |

The soluble salts (expressed on a fresh weight basis) in the ash are:— $K_2O$, 1·00 per cent.; $Na_2O$, 0·86 per cent.; CaO, 0·28 per cent.; MgO, 1·6 per cent.; Cl, 0·79 per cent.; $P_2O_5$., 0·14 per cent.

Its composition is strikingly different from that of most plants in that its protein and salt contents are high, whilst the respirable carbohydrates and crude fibre are exceptionally low. In itself it presents a well-balanced diet to sheep, provided water and roughage are available.

Its drought resistant properties depend on several factors. The most important are its metabolism and its peculiar structural make-up. Little starch is stored but chiefly pentosans; these, together with the proteins, have a high hydration capacity and hold water with great avidity. Furthermore, even during drought periods the rate of photosynthesis exceeds the rate of respiration, so that at no time does the plant live upon its carbohydrate reserves. The chief structural features contributing towards drought resistance are first, the presence of a very slightly cutinised epidermis which enables the leaf to absorb water from an atmosphere 85% saturated with water vapour; and second, its shallow root system which produces deciduous feeding roots only after rains.

### *(b) Ecotypes.*

The species, *Atriplex vesicarium,* is by no means a homogeneous one. At least three different ecotypes have been defined, one on hard loams of the Reserve type; another on silty soils on watercourses; and a third occurring on silty soils but also on sandy soils. Others possibly exist, especially a form on sandy plains and another around salt-lakes, but these have not been fully defined as yet. The three ecotypes which have been defined are illustrated in figs. 1 and 2, pl. v.

The ecotype on the travertine soils (Form A) is an erect twiggy bush with an average height of about 32 cms. and diameter of 34 cms. The leaf form is variable in outline, frequently lanceolate or with sinuate margins. The bladders on the fruiting calyx are small and sometimes absent.

The ecotype on silty soils (Form C) is a robust rounded bush, about 50 cms. high and with stout stems. Very large bladders are developed on the fruiting calyx. It presents the appearance often associated with tetraploid mutants.

The third form found on silty and also on sandy soils (Form B) is a very twiggy bush, about 40 cms. high, with narrow lanceolate leaves and generally without bladders on the fruiting calyx.

Only the first-mentioned ecotype occurs on the Reserve; this is the most drought resistant form of the three, and is the form on which grazing experiments have been performed at Koonamore (1). The saltbushes are gregarious and occur in clumps containing three or four individual plants. This is due to the fact that mounds of sand accumulate around the bases of the bushes and provide seedbeds in which seedlings of various sorts, including saltbush, germinate. The bushes do not form a continuous cover but are separated from one another by bare patches of soil. Flowering and fruiting may occur at any time of the year.

*(c) Regeneration.*

The factors controlling regeneration of *Atriplex vesicarium* are grazing by stock; length of life of the species; climatic conditions; the nature of the seedbed; and the presence of "nurse" plants, which disseminate seed, adjoining the eroded areas.

*(i) Length of Life.*

Under the conditions of drought which have prevailed during the last ten years the length of life of the form of *Atriplex vesicarium* found on the Reserve is about 12 years. On a hundred square metre quadrat (No. 10A), when laid down in 1926, there were 56 plants of *Atriplex vesicarium* present. Many of these were seedlings and did not survive beyond December, 1928, when 27 mature plants were present. Of these plants only eleven were alive in 1936, and all of these are sprawling bushes with only a few shoots bearing living leaves. The seedling mortality is high. Following winter rains in 1931, 178 plants of *Atriplex vesicarium* were listed in August, 1931, on this quadrat. Only 59 of these survived until June, 1932, but these established plants were all present and growing vigorously in June, 1936.

The length of life of the other ecotypes is not known. Observations in other parts of the North-East indicate that they are shorter lived and less drought resistant than the form under consideration.

*(ii) Climatic Conditions and Rate of Regeneration.*

The relation of regeneration to climatic conditions has been studied by means of quadrats and transects. Table II gives the numbers of *Atriplex vesicarium* plants present on a hectare quadrat (No. 100) within the Reserve on different dates.

TABLE II.

Numbers of *A. vesicarium* Plants present on Quadrat 100.

| Date. | No. of Plants. |
|---|---|
| 24-5-26 | 1 |
| 15-8-27 | 29 |
| 11-12-28 | 42 |
| 27-2-30 | 50 |
| 1-6-31 | 51 |
| 30-8-32 | 74 + seedlings |
| 30-10-33 | 129 |
| 22-8-35 | 170 |
| 26-5-36 | 167 |

Increases in the numbers of plants occurred after the winter rains of 1926, 1928 and 1931, and the summer rain of 1933. It is apparent, therefore, that species will germinate over a wide temperature range. The changes in Quadrat No. 100 are shown in the chart in text fig. 2.

In 1931 two transect lines were surveyed in the north-eastern corner of the Reserve; both lines commenced from a fence separating the Reserve from a paddock which contained a good stand of saltbush. Table III gives the numbers of *A. vesicarium* plants in 50 metres intervals along these lines at different times.

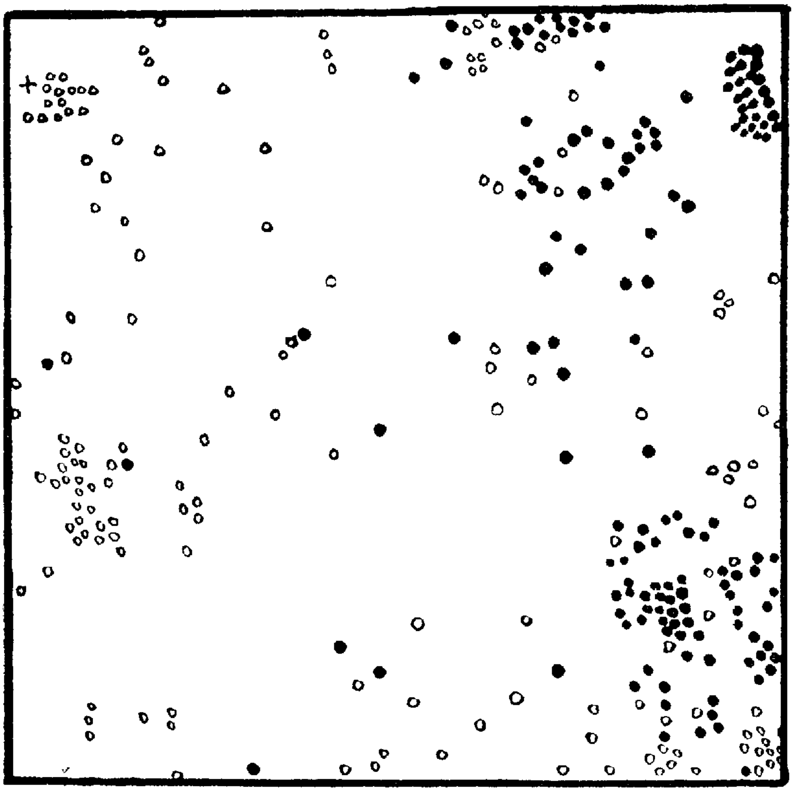

Fig. 2.

Chart of Quadrat No. 100, a hectare quadrat, in May, 1936, showing saltbushes *(Atriplex,* spp) present. Full circle represents plant of *Atriplex vesicarium,* open circle represents plant of *Atriplex stipitatum.* Only one *Atriplex* plant, that represented by a cross in the south-west corner of the quadrat, and now dead, was present when the quadrat was first started in May, 1926. Scale, $^1/_{1000}$.

TABLE III.

Numbers of Plants of *A. vesicarium* along transect lines.

Transect No. 1—

| Distance in Metres. | 0–50. | 50–100. | 100–150. | 150–200. | 200–250. | 250–300. | Total. |
|---|---|---|---|---|---|---|---|
| 24 6 31 - | 19 | 8 | 3 | 0 | 0 | 0 | 30 |
| 2–6–32 - | 17 | 34 | 34 | 4 | 0 | 0 | 89 |
| 25–5–33 - | 17 | 20 | 13 | 3 | 0 | 0 | 53 |
| 12–8–34 - | 33 | 26 | 16 | 6 | 0 | 2 | 81 |
| 21–8–35 - | 30 | 26 | 19 | 5 | 2 | 2 | 82 |
| 27–6–36 - | 32 | 26 | 19 | 5 | 1 | 2 | 85 |

TABLE III (continued).

Numbers of Plants of *A. vesicarium* along transect lines.

| Distance in Metres. | 0–50. | 50–100. | 100–150. | 150–200. | 200–250. | 250 300. | Total. |
|---|---|---|---|---|---|---|---|
| Transect No. 2 — | | | | | | | |
| 24–6–31 - | 19 | 15 | 2 | 1 | 3 | 0 | 40 |
| 2–6–32 - | 6 | 33 | 11 | 20 | 6 | 3 | 79 |
| 25–5–33 - | 10 | 31 | 13 | 3 | 1 | 2 | 60 |
| 12–8–34 - | 23 | 35 | 19 | 0 | 2 | 2 | 81 |
| 21–8–35 - | 22 | 33 | 15 | 1 | 2 | 2 | 75 |
| 27–6–36 - | 23 | 33 | 14 | 2 | 1 | 2 | 83 |

These transects show that substantial increases in numbers of bushes occurred after the winter rain of 1931, and also after the summer rain of 1933. The decrease in numbers between 1932 and 1933 is due to the fact that the 1933 figures include seedlings which had disappeared by 1933.

The transects also show that the greatest spread of the bush occurred after winter rains in 1931. Since that date there has been no further advance of bush over the barren soil of the Reserve. The summer rain of 1933, which was followed by a drought period, caused germination only in the area already occupied and chiefly in the mounds of sand which accumulate around established bushes.

*(iii) Nature of the Seedbed and Accessibility of Nurse Plants.*

It is conceivable that during a drought of extreme severity the shorter-lived forms of *Atriplex vesicarium* might be killed, but this is certainly not the case with the ecotype found on the hard loamy soils of the North-East.

Overstocking is the primary cause of degeneration. The saltbush communities are nicely balanced with their environment, as are all natural communities. It has been shown previously (1) that controlled moderately heavy stocking increases the vigour of the bush by pruning; overstocking results in death of the bush community.

Three stages resulting from overstocking can be distinguished:—

(1) The bush is killed but the dead sticks are not removed.
(2) The bush is removed, but the soil is still held by short-lived perennial plants.
(3) Total removal of all plant cover, so that the soil drifts and the bare stony sub-soil is exposed.

The cycle of events when the plant cover is totally removed is best shown in figs. 1 and 2, pl. vi. These photographs were taken around a bore put down in 1926 in an area which then carried good saltbush right up to the bore. In 1927, 6,000 sheep were watered at this bore for three months. The first photograph taken in 1929 shows how the bush cover has been totally removed and the surface is covered with drifting sand. Fig. 2, pl. vi, was taken in August, 1931, after winter rains. The plants are all annuals, the chief being:—*Zygophyllym fruticulosum, Z. ammophilum, Z. prismatolhecum, Z crenatum, Schismus calycinus, Tetragonia eremaea, Sida intricata, Helipterum floribundum, Babbagia acroptera, Atriplex spongiosum, Bassia paradoxa*, and *Salsola Kali*. No perennial plants were present, so that when the short-lived annuals died the sand again commenced to drift. Fig. 3, pl. vi, shows the area in 1935, when practically all the soil had been removed and the hard sub-soil exposed. Fig. 4, pl. vi, taken in 1936, shows the same area after rains. Regeneration of any plants on such exposed soil is impossible.

Figs. 1-4, pl. vii, show the cycle on areas where the bush has been removed but the soil is held by short-lived perennials, chiefly *Bassia patenticuspis, B. obliquicuspis*, and *B. sclerolaenioides*. This was the state of the soil in the Reserve

at the time of enclosure. The series of photographs were taken from a point within the Reserve removed from any *Atriplex* plants which would supply seed. In fig. 1, pl. vii, photographed in 1926, the ground is covered with the litter of the two *Bassia* species. Fig. 2, pl. vii, shows the changes after winter rains; the dominant plant is the speargrass, *Stipa nitida.* After summer rains, *Bassia* species and *Tetragonia eremaea* are dominant; fig. 3, pl. vii, shows the profusion of *Bassia,* spp., under such conditions. Fig. 4, pl. vii, photographed in 1936, shows the ground still held by the *Bassias* after extreme drought. The state of the soil is similar to that of the 1926 photograph but the gradual advance of the saltbush over this area may be seen in the background of fig. 4, pl. vii. A cycle exactly similar to this occurs in areas where the dead sticks of saltbush are not removed but remain standing.

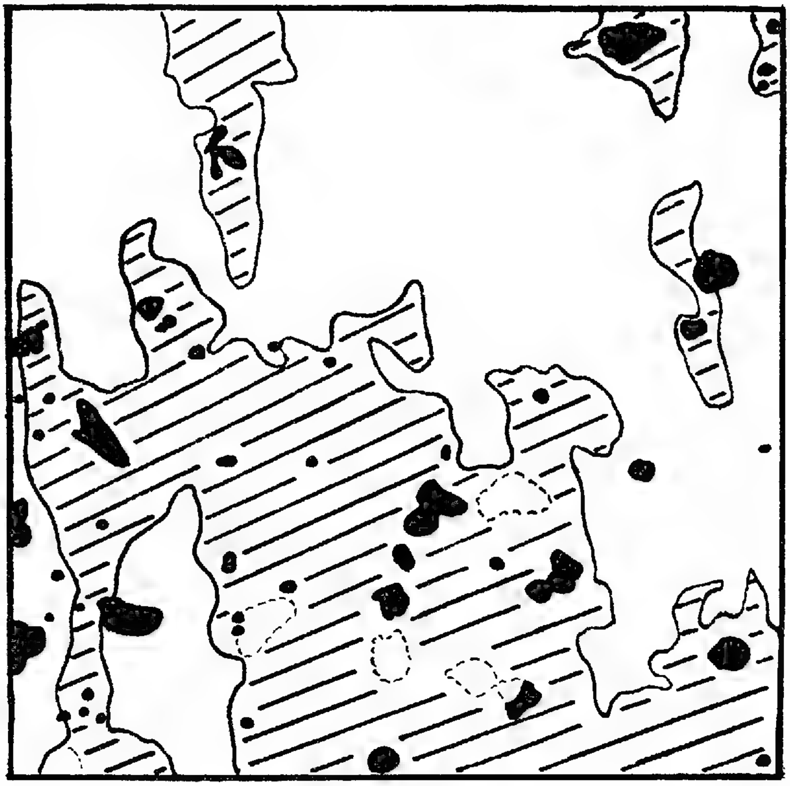

Fig. 3.

Chart of Quadrat No. 10A, a one-hundred square metre quadrat, showing distribution of *Atriplex vesicarium* in relation to *Bassia patenticuspis* and its litter The shaded area represents that covered with *Bassia patenticuspis* or its litter throughout the ten years' observations; the other area is bare, stony soil. The area of the canopy of the saltbushes is shown in black. Dotted areas represent dead bushes of saltbush. Charted May, 1936. Scale, 1/100.

The *Bassia,* spp., and their litter play a two-fold role in the regeneration of saltbush, first in preventing soil drift and second in holding mechanically the seeds of the saltbush. The light-winged fruits of *Atriplex* cannot remain stationary on the bare wind-swept soils, but the spines and litter of *Bassia* hold seeds effectively.

The chart in text fig. 3 is that of a 100 square metre quadrat (No. 10A), charted in 1936 *(i.e.,* after ten years' observation). The relation of saltbushes to *Bassia* is obvious. Figs. 1 and 2, pl. viii, show a portion of the same quadrat. The lack of regeneration of the bush on the bare stony area is clearly shown, whilst the marked regeneration on the outer *Bassia*-covered areas is equally marked.

One of the most important factors in regeneration is the presence of nearby nurse plants which shall provide seed for dissemination. The transect counts described above show how regeneration has occurred from seed derived from plants outside the Reserve fence. Figs. 3 and 4, pl. viii, show clearly the lack of regeneration when all seed plants are killed. Fig. 3, pl. viii, was photographed in 1925 at a point removed about 2 miles from the bore shown in figs. 1, 2, 3, 4, pl. vi. The healthy stand of bush outside the Reserve fences should be noted. Inside the Reserve the ground is bare but is held by *Bassia*, spp., and is of exactly the same type as that on which regeneration has occurred in other parts of the Reserve. Fig. 4, pl. viii, was photographed in 1936. It will be noted that no regeneration of bush has occurred. The reason is that all the bush outside the Reserve was killed in the early months of 1927 by the overstocking previously mentioned, when all the potential nurse plants were removed.

Whilst it is the object of this paper to describe the changes in vegetation which has occurred on the Reserve, it has been made quite clear to us that regeneration and maintenance of saltbush communities are not essentially problems for a botanist but are a question of management. The bush is not eaten by rabbits. Provided the equilibrium between the plants and their environment is not upset by overstocking, saltbush will withstand prolonged drought and regenerate readily.

### B. Atriplex stipitatum (Mallee Saltbush).

*Atriplex stipitatum* is a well-defined species, commonly known as "mallee saltbush." Within the Reserve it occurs mixed with *Atriplex vesicarium* to some extent on sandy patches, but is characteristic of deep sandy soils, which in the North-East carry mallee and black oak *(Casuarina lepidophloia)* as the dominant trees. It is not found in the treeless shrub steppe.

It approximates to *A. vesicarium* in chemical composition and structure but is unpalatable to stock on account of a bitter principle which it contains. Nevertheless, it is an important plant in arid areas, since it seeds freely, germinates readily, and consequently regenerates rapidly. It is a shorter-lived plant than *A. vesicarium;* the quadrat charts show that the average length of life of individual plants is about 8 years. *A. stipitatum* flowers and fruits during the summer months and is more exacting in its germination requirements than *A. vesicarium*.

Its regeneration in relation to rainfall may be seen from Table IV, which shows the number of *A. stipitatum* plants present in a hectare quadrat (No. 100).

Table IV.

Numbers of *Atriplex stipitatum* Plants on a Hectare Quadrat.

| Date. | No. of *A. stipitatum* Plants. |
|---|---|
| 24-5-26 | 1 |
| 15-8-27 | 3 |
| 11-12-28 | 61 |
| 27-2-30 | 63 |
| 1-6-31 | 68 |
| 30-8-32 | 155 |
| 30-10-33 | 163 |
| 22-8-35 | 170 |
| 26-5-36 | 179 |

It is clear from this table that germination occurred following early winter rains in 1926 and 1931. This is confirmed by transect counts (Table V) in the south-eastern corner of the Reserve. These transect lines were surveyed from a fence separating the Reserve, which was bare of *A. stipitatum* at the time of enclosure, from a paddock containing a healthy stand of this saltbush.

TABLE V.

Numbers of Plants of *A. stipitatum* along transect line.

| Distance in Metres. | 0–50. | 50–100. | 100–150. | 150–200. | 200–250. | 250–300. | 300–350. | 350–400. |
|---|---|---|---|---|---|---|---|---|
| Transect No. 3 – | | | | | | | | |
| 11–7–29 - | 48 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5–8–30 - | 71 | 3 | 1 | 0 | 0 | 0 | 0 | 0 |
| 24–6–31 - | 76 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3–6–32 - | 127 | 134 | 11 | 4 | 1 | 0 | 0 | 0 |
| 27-5–33 - | 85 | 39 | 4 | 4 | 0 | 0 | 0 | 0 |
| 14–8–34 - | 73 | 56 | 10 | 1 | 1 | 0 | 0 | 0 |
| 22–8–35 - | 55 | 50 | 3 | 2 | 1 | 0 | 0 | 0 |
| 29–5–36 - | 54 | 45 | 3 | 2 | 1 | 0 | 0 | 0 |
| Transect No. 4— | | | | | | | | |
| 11–7–29 - | 28 | 3 | 4 | 6 | 5 | 3 | 0 | 0 |
| 5–8–30 - | 35 | 5 | 7 | 5 | 2 | 2 | 0 | 0 |
| 24–6–31 - | 36 | 11 | 14 | 8 | 4 | 2 | 0 | 0 |
| 3–6–32 - | 151 | 137 | 121 | 35 | 29 | 26 | 27 | 8 |
| 27–5–33 - | 90 | 126 | 71 | 48 | 34 | 10 | 1 | 11 |
| 14–8-34 - | 95 | 106 | 103 | 25 | 26 | 15 | 1 | 1 |
| 22–8–35 - | 71 | 97 | 62 | 23 | 17 | 28 | 4 | 1 |
| 29-5-36 - | 72 | 95 | 57 | 21 | 20 | 28 | 4 | 2 |

In the period during which the transects have been run only one marked germination has occurred, *viz.*, after the winter rains of 1931. Comparison with the transects of *A. vesicarium* shows that in the case of *A. stipitatum* there are many more plants per 50 metres, and also that the area over which regeneration has occurred is much greater than is the case with *A. vesicarium.* On the other hand *A. stipitatum* is much less drought resistant than *A. vesicarium*, as is shown by the marked falling off in the number of plants per 50 metres during the drought years from 1932 to 1936. Figs. 1 and 2, pl. ix, show an area along Transect No. 3 in 1929 and 1936, respectively, and illustrate the marked increase in *A. stipitatum* plants during this period.

### C. KOCHIA SEDIFOLIA (Bluebush).

The "old man bluebush," *Kochia sedifolia,* occurs on soils where the travertine limestone comes close to the surface. It is a very long-lived perennial. At the onset of drought it loses its leaves more readily than do the saltbushes, and the stems die also. In this condition it will survive long and severe drought. After rains new shoots and roots are produced from patches of living tissue in the "stumps," which are contorted masses of stem and root bases. Figs. 3 and 4, pl. ix, show the condition of *K. sedifolia* during a wet season and after a prolonged drought.

*Kochia sedifolia* produces seeds only at infrequent intervals, and seedlings are rarely found. This is offset, however, by the longevity of the individual plants.

### D. MYOPORUM PLATYCARPUM (Sandalwood).

In the saltbush areas of the Reserve the sandalwood *(Myoporum platycarpum)* is the most important tree. In this area it reaches approximately the

northern limit of its range. Its fate in the North-East is one to cause concern, for it is dying out rapidly and no regeneration is taking place. The branches of sandalwood are pulled to provide feed for sheep in times of drought. This normally does not kill the tree.

During the 1928-1929 drought many trees became almost defoliated. In 1931, after the winter rains, vigorous new branches developed at the point of the main forking of the stem. During the prolonged drought from 1932-1936, however, many of the trees died. Table VI gives a comparison of sandalwood trees present on two quadrats in 1926 and 1936.

TABLE VI.

Numbers of Living Trees of *Myoporum platycarpum.*

| Quadrat. | 1926. | 1936. |
|---|---|---|
| 100 - - - | 33 | 22 |
| 400 - - - | 23 | 12 |

Figs. 1 and 4, pl. vii, and figs. 3 and 4, pl. viii, indicate the extent to which these trees have died. It is no exaggeration to state that approximately one-half of the trees living in 1926 were dead in 1936. Germination of the seeds of *Myoporum platycarpum* occurs frequently. Occasional seedlings have been recorded from time to time on the quadrats but none have survived except in special rabbit-proof enclosures. One such seedling, which appeared in an area on which the debris had been burnt and then enclosed from rabbits, is now (1936) a tree about 8 feet high. Regeneration of the sandalwood, as of trees generally in the pastoral country, is inhibited by the rabbit, which reaches plague numbers in good seasons.

### E. CASSIA STURTII AND CASSIA EREMOPHILA.

Before stocking became general, bushes of these two species were present in quantity, for the dead branches of the bushes are a feature of the landscape in the Reserve. *Cassia Sturtii* occurs on hard loam soils, whilst *C. eremophila* is more frequently found on sandy and silty soils. The seeds of both species germinate readily after heavy summer rains or after burning debris.

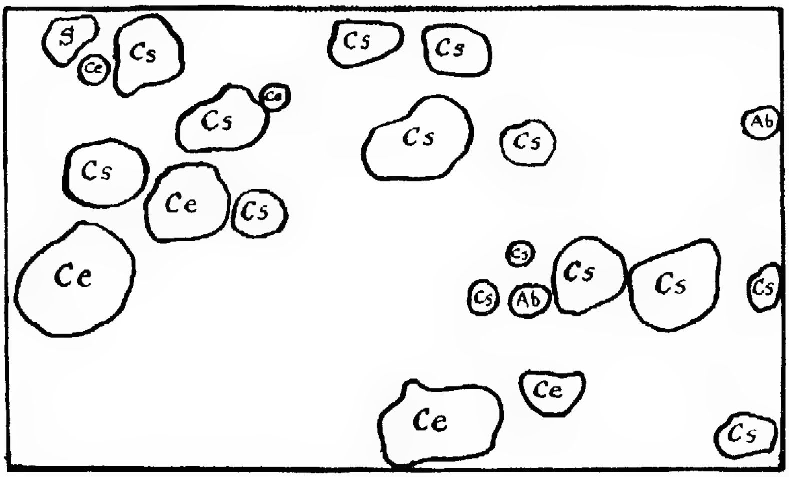


Fig. 4

Chart of Quadrat FR 6 in May, 1936. Debris was burnt in this area in May, 1928, and then enclosed from rabbits. The areas of the canopies of the different shrubs are shown. Cs, represents *Cassia Sturtii; Ce, Cassia eremophila;* Ab, *Acacia Burkittii;* and S, *Myoporum platycarpum.*. Scale, $^1/_{100}$.

Text fig. 4 is a chart of an area on sandy soil on which the debris was burnt in May, 1928, and then specially protected from rabbits. In June, 1928, 6 bushes of *C. eremophila* and 4 of *C. Sturtii* were present. By December, 1928, there were 5 bushes of *C. eremophila* and 12 of *C. Sturtii.* These bushes are still present in the enclosed area (1936), and in addition one extra plant of *C. eremophila* and two plants of *C. Sturtii* which appeared after the summer rains of 1933. The bushes are about 1 metre high and about 1 metre in diameter, and have seeded twice. Figs. 1 and 2, pl. xii, illustrate the regeneration in this area in 1928 and in 1936.

Seedlings of both species of *Cassia* became general over the Reserve after the heavy summer rains of 1929. During 1930-31 rabbits reached plague numbers in the Reserve and all the *Cassia* seedlings on the quadrats were grazed to ground level. Many of these were listed as dead in subsequent charts, but with the disappearance of the rabbits in 1931, many of the grazed plants produced new juvenile shoots from the base. A further germination of seedlings occurred after the summer rain of 1933. Table VII shows the pertinent data regarding *Cassia Sturtii,* on two hectare quadrats; No. 100 is on hard loamy soil, No. 300 on silty soil.

TABLE VII.

Numbers of *Cassia Sturtii* Plants on Hectare Quadrats.

| Quadrat No. | 1930. | 1936. |
|---|---|---|
| 100 - - - | 65 | 48 (1) |
| 300 - - - | 29 | 45 (2) |

(1) Includes 34 plants originally present in 1930.
(2) Includes 25 plants originally present in 1930.

## II—THE SANDHILL COMMUNITIES.

The sandhill communities of the Reserve are typical of those in the North-East as a whole. The climax community on the sandhills is an open scrub in which *Acacia aneura* (mulga) is the dominant tree, whilst the shrubs *Acacia Burkittii* (wattle) and *Eremophila Sturtii* (turpentine) are common. These three shrubs, apart from *Loranthus,* spp., parasitic upon them, comprise the only permanent members of the community. Before the introduction of stock *Cassia eremophila* was also common, but the latter has disappeared with the introduction of grazing, and regeneration is now prevented by the rabbit. All the above-mentioned trees on the Reserve, and indeed in the North-East generally, are old trees, and several counts of the annual rings in the wood of several different trees indicate that they are at least 40 years old. Mulga and wattle seedlings appear in the mature communities occasionally after heavy rains, and readily after burning; they are very slow-growing plants and never reach maturity, but are invariably eaten by rabbits. All these species, and especially *Acacia aneura,* have extensive root systems which effectively bind the loose sand.

However, these species, even if protected from rabbits, will not stabilise disturbed sandy soils, but pioneer species must first bring about a stable soil before the tree and shrubs can reach maturity. In most parts of the world the pioneer plants on sandhills, whether coastal or arid, are rhizomic perennial grasses. Tussocks at intervals along the rhizome and the roots of these plants effectively stabilise the soil and allow other plants, generally shrubs, to grow and reach maturity.

In arid Australia there are no such perennial plants, and the pioneers on sandhills are annuals. In a succession of good seasons the soil is stable long enough to permit the establishment of the shrubs and trees mentioned above, and even during short droughts the debris of the annual plants remain in the soil long

enough to allow establishment of shrubs. Although these perennial plants have appeared in the Reserve they have never survived, except in special rabbit-proof enclosures.

The nature of the pioneer annual plants on disturbed sandhills depends on the incidence of rain. After summer rain *Salsola Kali* var. *strobilifera* is the pioneer plant, and associated with it are *Chenopodium cristatum* and *Boerhaavia diffusa* (see fig. 2, pl. XA). Following late winter rains *Zygophyllum Billardieri* (fig. 1, pl. XA) is the chief pioneer plant. Both these plants are large shrubby annuals with shallow root systems and are readily blown away if a dry season intervenes; the sandhill then reverts to its original state. The most prolonged stabilisation of the soil occurs after early winter rains. The dominant plant under these circumstances is *Stipa nitida* (speargrass), a short-lived perennial, and associated with it are large numbers of ephemeral plants, especially *Helipterum moschatum, Tetragonia eremaea* and *Plagiobothrys plurisepala*. Figs. 1-6, pls. XA and XB, illustrate these pioneer changes on a disturbed sandhill in the Reserve. Fig. 1 shows *Zygophyllum Billardieri* as the dominant plant after the winter rains of 1928, whilst fig. 2 shows *Salsola Kali* as the dominant plant after the summer rains of 1930. *Stipa nitida* appeared in quantity after the heavy early winter rains of 1931 (fig. 3). Figs. 4, 5, 6, pl. XB, show the gradual disappearance of the speargrass under drought conditions. The final stage (fig. 6) shows a return to the original conditions—the surface is again loose and no shrubs have become established. On the mature scrub-covered sandhills the seasonal cycle is similar; *Salsola Kali* is the chief summer annual and *Stipa nitida* the dominant after winter rains. These changes are illustrated in figs. 1-4, pl. xi.

Yet shrubs, and especially mulgas, will regenerate if protected from rabbits, and the seedlings will also survive prolonged droughts. This has been shown in experiments on sandhill areas. Here the debris was burnt and portions of the burnt area enclosed by rabbit-proof fencing, whilst other equivalent areas were left unfenced to serve as controls. In one set of experiments the burns were made in August, 1927, seedlings appeared at the margins of the burns after the heavy rains of February, 1928. By June, 1929, there were 4 *A. aneura* seedlings in one quadrat (FR. 2) and 18 in another (FR. 4). During one night of July, 1929, a rabbit burrowed under the netting of FR4 and ate all the mulgas, except one. All the mulgas in the unfenced areas were eaten. Today (June, 1936) the enclosed mulgas are still growing vigorously.

Another area (FRA. 1) was burnt in June, 1929, and 4 *A. aneura* seedlings appeared after the rains of December, 1929, and a further seedling after the rains of October, 1930. These five seedlings are now small bushes, the tallest is about 4 feet high and the stem about ½ inch in diameter. Figs. 3 and 4, pl. xii, illustrate the regeneration on Quadrat FRA. 1 in 1929 and in 1936.

It appears, therefore, that *A. aneura* will germinate after summer rains and is stimulated by fire. It is extremely drought resistant even in the seedling stage, but regeneration under natural conditions is inhibited by the rabbits.

## III—WATERCOURSE COMMUNITIES.

The silty flats and watercourses are important after rains. The plant community found there is an ephemeral one showing well marked seasonal aspects, and the wealth of species and of individuals makes this community a valuable one as to the pastoralist. It presents few problems of regeneration, since the plants are annuals and the soil contains such a high percentage of silt and clay that it has no tendency to drift. The chief of the problems which this community is likely to present in the future is the capture of the habitat by alien plants. In parts of the North-East *Diplotaxis tenuis,* (Teetulpa weed), *Xanthium spinosum*

(Bathurst Burr), and *Reseda luteola* (weld) have been observed to totally replace the more valuable native annuals. In the Reserve these plants do not occur.

Trees and shrubs are infrequent, although a tree, *Eremophila longifolia,* occurs occasionally. The cycle of events on silty soils is best described by the series of photographs shown in figs. 1-4, pls. xiii and xiv, taken from a point within the Reserve. Fig. 1, pl. xiii, shows the vegetation after summer rains. The dominant plants on silty soils are *Erodium cygnorum* (geranium) and *Erodiophyllum Elderi* (Koonamore daisy); *Zygophyllum crenatum* and *Z. iodocarpum* are also important. On sandy-silt soils *Zygophyllum prismatothecum* is dominant.

Fig. 2, pl. xiii, shows the vegetation after winter rains and consists of *Stipa nitida* (speargrass), which is dominant, together with young plants of *Erodium cygnorum* (geranium) and *Bassia patenticuspis.*

Fig. 3, pl. xiv, shows the flat after prolonged drought. The soil is littered with the woody heads of *Erodiophyllum Elderi.* Fig. 4, pl. xiv, shows the flat after a late summer thunderstorm. The dominant plant is *Erodiophyllum Elderi,* whilst *Erodium cygnorum, Lotus australis, Bassia patenticuspis,* and *Clianthus speciosus* are also present. In this photograph the shrubs in the middle distance are *Eremophila longifolia* which have appeared on the flat.


### Acknowledgments.

Acknowledgments are especially due to Professor T. G. B. Osborn, now of the University of Sydney, through whose efforts the Koonamore Vegetation Reserve was established and who was Director of the Reserve from 1926 to 1931. Many of the observations from 1926 to 1931 quoted in this paper were made by him or by T. B. Paltridge, an officer of the Council for Scientific and Industrial Research, who was stationed at the Reserve from 1928 to 1931.


## SUMMARY.


1. This paper presents an account of the regeneration of vegetation which has occurred in the Koonamore Vegetation Reserve over a period of ten years.
2. During the whole of this period the rainfall has been subnormal.
3. The factors influencing regeneration of saltbushes *(Atriplex vesicarium* and *A. stipitatum)* are the nature of the grazing, length of life of the species, climatic conditions, nature of the seedbed and presence of seed-dispersing plants. Quantitative measurements of these factors and their effect on regeneration are given. Control of these areas can only be effected by adequate management of grazing.
4. The sandhill community is discussed. The pioneer plants are annual plants, which only in good seasons stabilise the soil long enough to permit development of shrubs and trees. Regeneration of the latter is inhibited by the rabbit. Quantitative measurements of regeneration are presented.
5. Watercourse communities are not subject to drift, but carry a wealth of annual plants with marked seasonal aspects.


### References.


(1) Osborn, T. G. B., Wood, J. G., and Paltridge, T. B. On the Growth and Reaction to Grazing of the Perennial Saltbush, *Atriplex vesicarium.* Proc. Linn. Soc. N.S.W., **vol. xlvii,** p. 377, 1932.

(2) Osborn, T. G. B., Wood, J. G., and Paltridge, T. B. On the Climate and Vegetation of the Koonamore Vegetation Reserve to 1931. *Ibid,* **vol. l,** p. 392, 1935.

## DESCRIPTION OF PLATES.

### Plate V.

Ecotypes of *Atriplex vesicarium.*

Fig. 1. Form A on travertine loam in Koonamore Vegetation Reserve.
Fig. 2. Forms B and C on Tin Hut Watercourse.

### Plate VI.

Series of photographs taken from a point at an overstocked bore.

Fig. 1. February, 1929. Saltbushes removed and surface covered with drifting sand.
Fig. 2. August, 1931. Annual plants (chiefly *Zygophyllum*, spp.) on sandy patches after winter rains.
Fig. 3. August, 1935. After prolonged drought. Sand totally removed and sub-soil exposed.
Fig. 4. May, 1936. Lack of regeneration of annuals on exposed sub-soil after summer rains.

### Plate VII.

Cycle of vegetation changes in overstocked saltbush community. The bushes have disappeared but the soil is still held by *Bassia*, spp.

Fig. 1. May, 1926. Soil covered with litter of *Bassia patenticuspis.*
Fig. 2. December, 1926. *Stipa nitida* (speargrass) dominant after winter rains.
Fig. 3. June, 1931. *Bassia*, spp., dominant after summer rains.
Fig. 4. May, 1936. After prolonged drought. Soil still held by *Bassia*, spp. Compare this photograph with that of May, 1926, and note that practically all the sandalwood trees have died.

### Plate VIII.

Two areas showing regeneration of saltbush.

Fig. 1. May, 1926. Portion of Quadrat No. 10a.
Fig. 2. May, 1936. Portion of same quadrat showing regeneration of *Atriplex vesicarium* in background and lack of regeneration on hard, stony soil, in foreground.
Fig. 3. March, 1925. View along fence separating Reserve (foreground) from an outside paddock. Note good stand of saltbush outside Reserve. This was killed by overstocking early in 1927.
Fig. 4. May, 1936. View from same point. Notice lack of regeneration inside Reserve, although the soil is suitable, due to removal of plants which would form seed. Compare trees in two photographs and note that all the sandalwoods have died.

### Plate IX.

Two areas showing vegetation variations over several years, as set out in context.

Fig. 1. September, 1929. View along one of line transects to study regeneration of *Atriplex stipitatum.*
Fig. 2. May, 1936. View from same point, showing marked regeneration of *Atriplex stipitatum.*
Fig. 3. August, 1931. View along fence separating Reserve (right) from an outside paddock. Outside well foliated bluebush *(Kochia sedifolia)*; inside, in background, note regeneration of bluebush from stumps, foreground *Stipa nitida* after winter rains.
Fig. 4. August, 1935. View from same point. Bluebushes completely defoliated.

### Plate Xa.

Cycle of vegetation changes on a disturbed sandhill.

Fig. 1. July, 1928. *Zygophyllum Billardieri*, pioneer plant after late winter rains.
Fig. 2. March, 1930. *Salsola Kali* var. *strobilifera*, pioneer plant, summer rains.
Fig. 3. August, 1931. *Stipa nitida* and annuals, pioneer plants after early winter rains.

### Plate Xb.

(Continued from Plate Xa.)

Fig. 4. June, 1932. Death of *Stipa nitida* at onset of drought.
Fig. 5. May, 1933. Drought still prevailing, but stumps of *Stipa nitida* still holding sand.
Fig. 6. May, 1936. Drought still prevailing and sandhill bare except for few small *Salsola* plants.

## Plate XI.

Cycle of vegetation changes on stable sandhill.

Fig. 1. May, 1936. Sandhill stabilised by climax community of *Acacia aneura* (mulga).
Fig. 2. December, 1926. *Stipa nitida* dominant after winter rains.
Fig. 3. June, 1931. *Bassia paradoxa, Erodium cygnorum* and *Stipa nitida* after summer rains, followed by winter rains.
Fig. 4. May, 1936. *Salsola Kali* after summer thunderstorm.

## Plate XII.

Two areas showing regeneration of trees and shrubs.

Fig. 1. June, 1928. View of area on which debris burnt and enclosed from rabbits.
Fig. 2. May, 1936. View of same enclosure from a different angle, showing regeneration of *Cassia Sturtii* and *C. eremophila* within enclosure.
Fig. 3. December, 1929. View of area on which debris burnt and enclosed from rabbits.
Fig. 4. May, 1936. View of same area, showing young plants of mulga *(Acacia aneura)* which have appeared within enclosure.

## Plate XIII.

Cycle of vegetation changes on a flooded area with silty soil.

Fig. 1. July, 1928. After summer rains followed by winter rains. *Erodium cygnorum* (geranium) dominant.
Fig. 2. August, 1931. *Stipa nitida* (speargrass) dominant after winter rains.

## Plate XIV.

(Continued from Plate XIII.)

Fig. 3. May, 1934. Area bare after prolonged drought. Flat covered with woody capitula of *Erodiophyllum Elderi.*
Fig. 4. May, 1934. *Erodiophyllum Elderi* dominant after summer rains. Note appearance of bushes of *Eremophila longifolia* in mid-distance.

# STUDIES IN AUSTRALIAN THYSANURA.
# NO. 1. A NEW SPECIES OF LEPISMATIDAE FROM SOUTH AUSTRALIA.

*BY H. WOMERSLEY, F.R.E.S., A.L.S.*

## Summary

The species of Silver Fish described in this paper is interesting in that it constitutes the first record of a species of Nicoletia (subfamily Nicoletinae) from Australia.

The subfamily Nicoletinae comprises the Lepismids in which the eyes are wanting, the last segment of the labial palp with sensory papillae, and the gonapophyses sword-like or clubbed. It includes a number of both scaled and unsealed species, the first section of which contains a large number of species belonging to a number of genera, confined to the nests of ants and termites.

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[Read September 10, 1936.]

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The subfamily Nicoletinae comprises the Lepismids in which the eyes are wanting, the last segment of the labial palp with sensory papillae, and the gonapophyses sword-like or clubbed. It includes a number of both scaled and unscaled species, the first section of which contains a large number of species belonging to a number of genera, confined to the nests of ants and termites. In the non-scaled section are the three genera, *Trinemophora* Schaeff., *Nicoletia* Gerv. and *Trinemura* Silv., which may be separated by the following key:—

1. Exsertile vesicles present on segments VII or II-VIII; stylets present on II-IX or on III-IX.
   Exsertile vesicles absent; stylets only on VIII and IX. — *Trinemophora* Schaeff., 1897
2. Exsertile vesicles only on VII; stylets present on III-IX — *Trinemura* Silv., 1908
   Exsertile vesicles on segments III-VIII; stylets on II-IX. — *Nicoletia* Gerv., 1842

### Nicoletia australis, sp. n.

(Text fig. 1, A-Q.)

*Description.*—Length of body, ♂ ♀, 8-9 mm.; antennae, half the length of body; cerci, three-fourths length of body. Eyes absent. Exsertile vesicles present on sternites II-VIII, stylets on II-IX. Eyes absent. Median tail appendage ventrally with a double series of setae. Legs as figured; claws, three (*cf.* fig. 1, Q). Mandibles with five apical teeth and a series of short spines. Maxillary palpi as in fig. 1, F. Labial palpi with apical segment globose with sensory papillae. Thorax as wide as abdomen. Posterior margins of thoracic and abdominal segments with a row of strong setae.

♂ second basal segment of antennae with an inner apophysis and a series of strong setae; genital segments as in fig. 1, N.

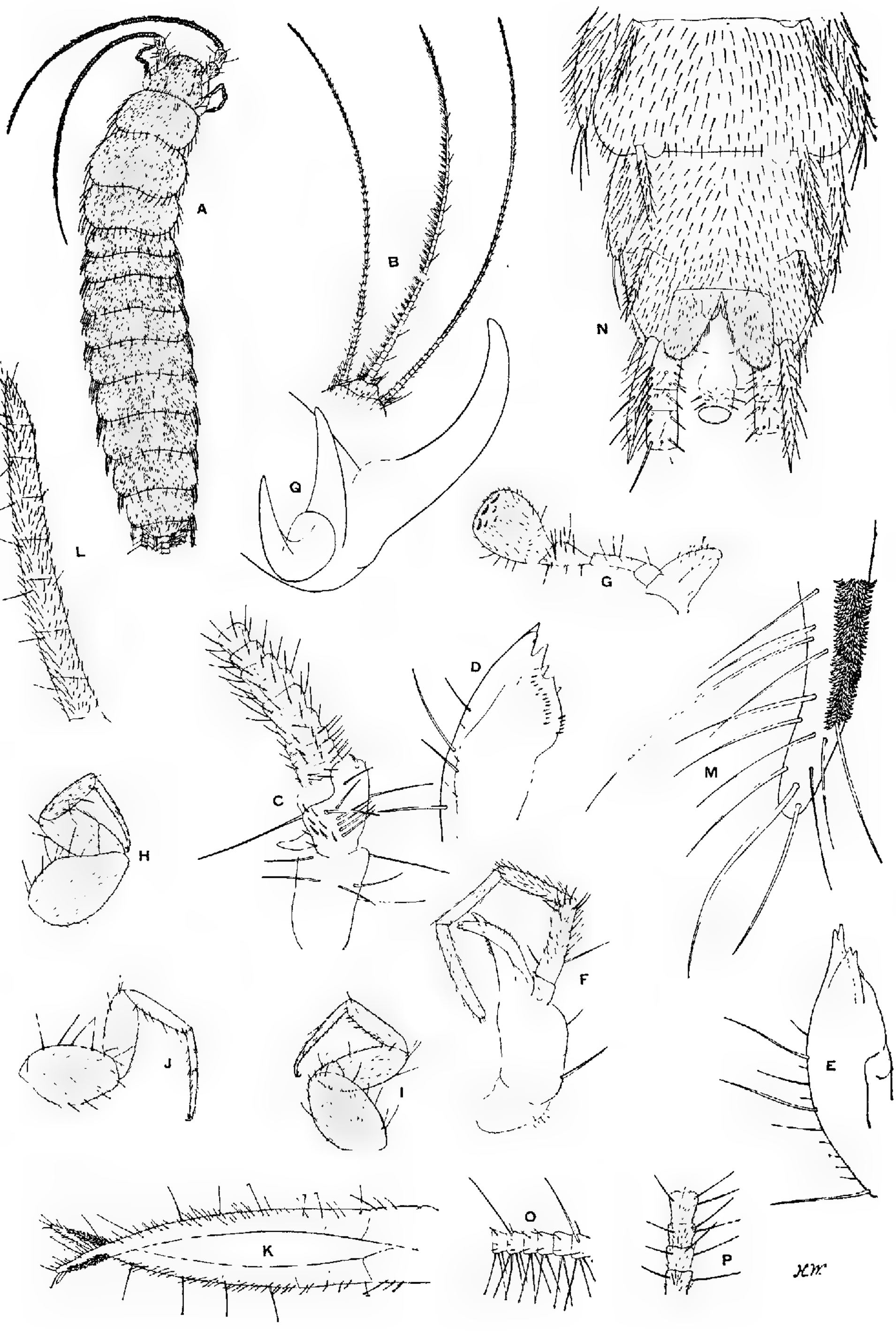
♀ anterior gonapophysis as in fig. 1, L; posterior gonapophyses subapically with an inner series of closely placed curved hooks (cf. fig. 1, K. M.).

*Locality.*—Several males and an immature female taken from a rotten log in the National Park, Belair, South Australia, July 12, 1936 (J. S. W.), and several more males and an adult female from the same log, July 19, 1936 (J. S. W. and H.W.).

EXPLANATION OF TEXT FIGURES.

1, A-Q. *Nicoletia australis*, sp. n.

A. Dorsal view of insect without cerci. ♂.
B. Cerci and median tail appendage of same. ♂.
C. Basal segments and base of antennal flagellum. ♂.
D. Mandible. ♂.
E. ,, another view. ♂.
F. Maxillary palp. ♂.
G. Labial palp. ♂.
H. First leg. ♂.
I. Second leg. ♂.
J. Third leg. ♂.
K. Posterior gonapophyses. ♀.
L. Anterior gonapophysis. ♀.
M. Tip of posterior gonapophysis. ♀.
N. Segments VIII-X of male from below.
O. Basal segments of median tail appendage. ♂.
P. Basal segments of cerci. ♂.
Q. Claws. ♂.


A
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H.W.

# THE BOTANICAL FEATURES BETWEEN OODNADATTA AND ERNABELLA IN THE MUSGRAVE RANGES, WITH A LOCALITY LIST OF PLANTS FROM THE NORTH-WEST OF SOUTH AUSTRALIA IDENTIFIED BY MR. J, M. BLACK, A.L.S.

*BY J. BURTON CLELAND, M.D.*

## Summary

During the Seventh Expedition, organised by the Board for Anthropological Research of the University of Adelaide, in conjunction with the South Australian Museum, for the study of the Australian aborigine, to Ernabella in the Musgrave Ranges, opportunity was taken as circumstances permitted to make notes on the flora of the country visited. In addition to a study of the uses made by the natives of the plants in the Musgrave Ranges, and their names for these, and the general ecological relationship of the natives to the vegetation, notes on the various plants seen were taken during each mile of the journey there and on part of the way back. Ernabella itself is in the eastern part of the Musgrave Ranges, nearly 300 miles north of west of Oodnadatta. Travel was by motorcar and motor lorries, the outward route being the southern one. This ran for about 75 miles, more or less, along the southern branch of the Neales Creek. After descending from a gibber tableland, a branch of Arkaringa Creek was crossed at 87 miles. After leaving Wellbourne Hill Station (Mr. Giles) at 100 miles, the track passed north-west to Wantipella Swamp (159 miles), on which is situated Indulkana hut. It there passes west to Mount Chandler Station (175 miles) and on to Moorilyanna Rocks and Station (193 miles). From here the route is again north-west through Echo Hill (219 miles), across Tietkens' Birthday Creek (270 miles), and on to Ernabella in Glen Ferdinand (277 miles). The return journey left this track a few miles west of Indulkana, passing more or less east, or even north-east at times, through Granite Downs (about 20 miles from Mount Chandler and 158 from Oodnadatta) to Lambinna (107 miles from Oodnadatta) on the Alberga, Todmorden Station (60 miles from Oodnadatta) where the Alberga is again crossed, and then over extensive plains to Oodnadatta.

# THE BOTANICAL FEATURES BETWEEN OODNADATTA AND ERNABELLA IN THE MUSGRAVE RANGES, WITH A LOCALITY LIST OF PLANTS FROM THE NORTH-WEST OF SOUTH AUSTRALIA IDENTIFIED BY MR. J. M. BLACK, A.L.S.

By J. Burton Cleland, M.D.

[Read September 10, 1936.]

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The country between Oodnadatta on the one hand, and Indulkana and Granite Downs on the other, is essentially what is known as "tableland" with frequent gibber plains and rises and scattered table top hills. It is crossed at intervals by broad, usually dry, watercourses, near which may be flood plains. The country gradually rises as one proceeds eastwards to over 1,000 feet above Oodnadatta, which itself is 397 feet above the sea. This gradual rise continues towards the Musgrave Ranges, where the plains may be nearly 2,000 feet above Oodnadatta's level. Mulga scrub occurs frequently between the gibber plains or scattered sparsely over them. Along the watercourses, for 50 miles from Oodnadatta, gidya *(Acacia Cambagei)* is met with. Near Oodnadatta the coolebah or box *(Eucalyptus microtheca)* is found on the flats near the creek, but further east Red Gums *(E. rostrata)* are more usually in the creek beds.

The gibbers themselves vary in size, those in any one area being all of approximate size. This may be from an inch or less to rocks nearly the size of an infant's head. The smaller ones become flat and polished (the desert glaze) and may be closely set as in a pavement, covering more than half of the surface, or the stones may be more scattered. The gibber areas may be almost quite devoid of shrubs or show scattered groups of mulga *(Acacia aneura)* or occasional

shrubs of dead finish *(A. tetragonophylla)* or species of *Cassia* and *Eremophila*. The most interesting features of the gibber "tablelands" are the "crab-holes," slight depressions, generally about the size of a dinner-table, which may be numerous, only a few yards separating them, widely scattered or almost absent. The "crab-holes" are devoid of gibbers, and after rain become boggy and spongy and may hold water. In these a wealth of ephemeral plants spring up after rains and, as such had recently fallen, many were already in flower at the time of our visit. From place to place the species vary. Thus about 20 miles east of Oodnadatta were noted the grasses *Astrebla pectinata* (Mitchell Grass), *Tragus racemosus*, and *Iseilema vaginiflora; Frankenia planifolia, F. flabellata* and *F. serpyllifolia, Lotus australis* var. *parviflorus, Pimelea simplex, Goodenia subintegra, Centipeda thespidioides, Helichrysum podolepideum, Senecio Gregorii* and other composites.

A few miles further on were seen *Triglochin calcitrapa*, nardoo *(Marsilea hirsuta)* and the leaves of a *Crinum*. In other crab-holes, species of *Bassia (B. uniflora, B. lanicuspis, B. intricata, B. divaricata* and *B. Blackiana), Malacocera tricornis*, species of *Kochia (K. eriantha, K. spongiocarpa, K. ciliata* and *K. brachyptera)*, and of *Atriplex (A. vesicarium, A. Quinii, A. fissivalve, A. halimoides* var. *conduplicatum* and *A. spongiosum)* predominated, or crucifers *(Blennodia nasturtioides, Lepidium oxytrichum* and *Stenopetalum lineare* var. *canescens)* occurred.

## Plains between Moorilyanna and Ernabella.

The 80 miles between Moorilyanna and Ernabella is essentially mulga scrub, at times dense but mostly open, with a break at 25 miles from Moorilyanna when the track passes through a gorge in Echo Hill and with occasional sandy patches. As Ernabella is approached, outlying hills and rocks and watercourses from the Musgrave Ranges are met with. The mulga scrub consists chiefly of *Acacia aneura*, with some examples of the broad-leafed var. *latifolia* and witchetty bush *(A. Kempiana)* with occasional small trees and shrubs such as the needle bush *(Hakea leucoptera)*, corkwood *(H. lorea)*, a shrubby *Grevillea*, the prickly *Acacia Victoriae*, dead-finish, *Pittosporum* and *Eremophila*, spp. Beneath these were dead looking tufts of mulga grass *(Aristida)*, and under-shrubs of *Kochia* and *Bassia*.

At Echo Hill, amongst the rocks, grew the fern *Notholaena, Amaranthus, Parietaria debilis, Erodium cygnorum*, crucifers, *Oxalis, Chenopodium*, bloodwood, native fig, *Tecoma*, the everlasting *Myriocephalus Stuartii* and *Sarcostemma* with its snake-like branches. On a flat almost exactly half-way across giant saltbush and samphire grew, and on the surrounding sandy rises, *Myriocephalus, Calandrinia, Salsola Kali*, the dainty crucifer *Menkea sphaerocarpa*, the cucumber *Melothria, Pittosporum, Grevillea* and the mallee *Eucalyptus oleosa*. *Eucalyptus intertexta* grew on the flat of a watercourse near Ernabella.

## Ernabella and Its Surroundings.

Ernabella itself is situated in a usually dry watercourse, the Ernabella or Ferdinand Creek, in the picturesque Glen Ferdinand, a more or less flat valley hemmed in by tall and rugged *Triodia*-covered sloping mountain masses. These flat valleys, resembling those in the MacDonnell Ranges, are characteristic also of the Musgrave Ranges, at least of the eastern half seen by the expedition. They wind in and out among the hills which rise abruptly from the plain without any noticeable rise or heaps of debris at the junction and are traversed by watercourses. Glen Ferdinand itself is several miles long, narrow in places, but a

quarter of a mile or more in others. Interspersed along the sides or towards the centre are knolls and low hills of jumbled rocks, succeeded further back by mountains such as Mount Ferdinand. The vegetation can be divided up into that of these plains or glens, of the watercourses, of the rocky knolls and of the mountain slopes.

*The Plains or Glens* are open stretches with widely seperated shrubs and small trees of witchetty bush *(Acacia Kempeana)*, the corkwoods *Hakea lorea* and *H. Ivoryi* and *Acacia Victoriae*, with occasional herbs such as *Swainsona villosa*. Abutting on the creek to the east was an extensive flat of giant saltbush *(Atriplex nummularium)* and similar flats, holding water after rains and known as swamps, were met with occupying some acres in extent between Ernabella and Upsan Downs (23 miles east) and Erliwanjawanja Rock Hole (37 miles east) along the southern side of the ranges. On the road to the last-named waterhole, on the plains between outliers of the ranges, the vegetation changed somewhat from time to time. Thus mulga *(Acacia aneura)*, scattered or moderately dense, was a feature of some parts, ironwood *(A. estrophiolata)* with its characteristic change of foliage from the juvenile to the adult state of others, whilst open spaces were sometimes occupied by small species of *Atriplex* or of *Kochia*. An occasional *Pittosporum phillyraeoides* or dead finish *(A. tetragonophylla)* also occurred. *Nicotiana Gossei*, a species chewed by the natives, grew round Erliwanjawanja Rock Hole.

*Ernabella Creek and other similar Watercourses* grew picturesque examples of red gums *(Eucalyptus rostrata)*, the trunks often as white as those of *E. papuana*, and the sucker leaves broader and their stems more quadrangular than is the case near Adelaide. Two or three examples of another species of Eucalyptus *(E. bicolor* var. *xanthophylla)*, with spreading, scrambling branches, also grew near Ernabella. Black Teatree *(Melaleuca monticola)*, with dark rough bark, and *M. glomerata*, with papery bark, grew near or in the bed with clumps of sedges *(Cyperus vaginatus)*—the rushes of the explorers—and the herb *Samolus repens*, here with small pink flowers. In the beds of the creeks, water is held up in places as at Ernabella itself. The heads are in mountain ravines, and where the rock surfaces are suitable pools of water may be found for months after rain. Two such rockholes were visited lying 8 and 10 miles north of Ernabella, close to the track through the east end of the Musgraves to their northern aspect, and so round to Opperrinna. These and a ravine a few miles west of Ernabella showed an abundance of plants, mostly herbaceous. These included *Nicotiana excelsior*, whose leaves are chewed by the natives as a narcotic, which was coming up in abundance; it has smooth, glossy leaves, fragrant flowers, and one example seen was a handsome plant about 3 feet 6 inches high and several feet wide, a mass of white blooms. Other under-shrubs and herbs seen included *Stemodia viscosa, Pterocaulon sphacelatum, Trichodesma zeylanicum*, the introduced sow thistles *Sonchus oleraceus* and *S. asper* (the former quite common), several *Malvaceae (Sida virgata* var. *phaeotricha* and *Hibiscus Sturtii)*, *Trichinium obovatum*, the fern *Gymnogramme Reynoldsii* (much larger than its minute southern relative *G. leptophylla)*, a white-flowered herbaceous heliotrope *(Cynoglossum australe* var. *Drummondii)*, the minute *Crassula Sieberiana*, the prickly *Solanum petrophilum*, and a few large plants of the handsome prickly *Acacia strongylophylla*.

*The Boulder-strewn Knolls and Lower Hills.*—Scattered round the bases of the mountain sides or sometimes situated as isolated units in the adjacent plains were small knolls, hills or ridges covered with large tumbled gneissic boulders. In the decomposed soil between these grew a number of shrubs, under-shrubs and herbs. The shrubs included dead-finish *(A. tetragonophylla), A. Kempeana*, mulga

which was abundant on some low hills and absent in other places, native cypress pine *(Callitris glauca)*, also abundant on some hills and rare or absent on others but not growing with the mulga, the scrambling native fig *(Ficus platypoda)*, sometimes *Hakea lorea*, *Santalum lanceolatum* in places, *Dodonaea petiolaris*, a few plants of *Rhagodia spinescens*, occasionally giant salt-bush *(Atriplex nummularium)* (a wanderer from the society of this in the adjacent plain), *Cassia*, the green-flowered *Eremophila serrulata*, the fuchsia-flowered *E. longifolia*, and often near the base or extending on to the adjacent plain the picturesque *Pittosporum phillyreoides*. The very prickly *Solanum petrophila*, with handsome large blue flowers, was also common, but *S. ellipticum*, the fruit of which is eaten, was rare. The snake-like branches of *Sarcostemma australe* formed intricately-twined masses. More lowly plants included the fern, *Notholaena Brownii*, exceedingly common in rock crevices, *Erodium cygnorum* with blue or pink flowers, *Amaranthus Mitchellii* sometimes less than an inch high, *Isotoma petraea* very abundant in places and rarely extending on to the adjacent flats, *Parietaria debilis* in shady spots moistened by recent rains, a few plants of the pea *Glycine clandestina*, rarely *Justicia procumbens*, *Euphorbia Drummondii* and sometimes *E. australis*, and scattered grasses such as kangaroo grass *(Themeda australis)*, *Digitaria Brownii (Panicum leucophaeum)*, *Paspalidium gracile*, etc.

*The higher Hills and Mountains.*—The higher hills and mountain masses have steeply sloping sides covered with rocks and pale coloured porcupine grass *(Triodia aristata)* in about equal amounts. At their bases, where more water has collected, the *Triodia* clumps may reach 2 feet 6 inches in height and 4 feet in breadth. Whilst practically the only vegetation in the exposed areas is the *Triodia*, in the ravines and lower portions a few other plants are to be found, the species merging into those of the rocky knolls and of the heads of the streams. Figs may scramble over the rocks even at some considerable height, *Tecoma doratoxylon* (used for spears) grows usually near the bases, bloodwoods *(E. terminalis)* straggle round the base and lower slopes of some hills, as does *Pittosporum*. *Loranthus Miquelii*, with yellowish brown leaves, is common on the bloodwood. The white-flowered *Heliotropium asperrimum* is often found in the lower parts between the *Triodia*. Occasionally Sturt's desert rose *(Gossypium Sturtii)* also was found on the lower slopes as well as *Eremophila longifolia* with fuchsia-like flowers, *Solanum petrophila* (very prickly) and rarely the harsh-leaved *Wedelia*.

## List of Plants Collected in the North-East of South Australia.

(Identifications made or confirmed by Mr. J. M. Black. The records include some obtained on previous expeditions.)

Filicales: –

*Cheilanthes tenuifolia* Swartz. Erliwanjawanja.

*Notholaena Brownii* Desv. Echo Hill, Ernabella.

*Gymnogramme Reynodlsii* F. v. M. Amongst granitic rocks, rockholes, 8 and 10 miles north of Ernabella.

*Marsilia hirsuta* R. Br. 22 miles west of Oodnadatta.

*M. Drummondii* R. Br. Ross Waterhole, on the Macumba, near Oodnadatta.

Pinaceae:—

*Callitris glauca* R. Br. Ernabella, Erliwanjawanja.

Typhaceae:—

*Typha angustifolia* L. Hamilton Bore.

Potamogetonaceae:—

*Potamogeton* sp. Dam at Oodnadatta.

Scheuchzeriaceae:—

*Triglochin calcitrapa* Hook. 22 miles west of Oodnadatta.

Gramineae:—

*Pollinia fulva* (R. Br.) Benth. Ross Waterhole, Hamilton Bore.

*Andropogon exaltatus* R. Br. Ernabella, rockhole 10 miles north of Ernabella.

*Themeda triandra* Forsk. Ernabella.

*Iseilema vaginiflora* Domin. 16 miles west and north-west of Oodnadatta.

*I. actinostachys* Domin. Abminga.

*Tragus racemosus* (L.) Haller. William Creek (Dec.), 16 miles west of Oodnadatta, Ross Waterhole.

*Eriochloa punctata* (L.) Hamilt. Ross Waterhole, Hamilton Bore.

*E. punctata* var. *acrotricha* Benth. (? *E. pseudo-acrotricha* Hubb.) 16 miles west of Oodnadatta, Ross Waterhole.

*Digitaria Brownii* (R. et S.) Hughes *(Panicum leucophaeum)*. Echo Hill, between Moorilyanna and Ernabella, Ernabella.

*D. coenicola* (F. v. M.) Hughes. Blood Creek.

*Paspalidium gracile* (R. Br.) Hughes. Ernabella (also dwarf form), Ross Waterhole.

*Panicum decompositum* R. Br. Edward Creek, Gypsum Bore (50 miles west of Oodnadatta), also 16 miles west.

*Spinifex paradoxus* (R. Br.) Benth. Ross Waterhole, Hamilton Bore.

*Aristida arenaria* Gaudich. Ernabella, 15 miles west of Oodnadatta, Ross Waterhole.

*A. echinata* Henr. var. *nitidula* Henr. Ernabella and rockhole, 10 miles north.

*A. anthoxanthoides* (Domin.) Henr. 15 and 20 miles west of Oodnadatta.

*Stipa nitida* S. et H. North of Marree; north of Irrapatana.

*Sporobolus actinocladus* F. v. M. Oodnadatta.

*Eriachne aristidea* F. v. M. Ross Waterhole.

*E. ovata* Nees. Ross Waterhole.

*E. ovata* var. *pallida* Benth. Ross Waterhole.

*Pappophorum nigricans* R. Br. Ernabella, Hamilton Bore, Blood Creek.

*P. avenaceum* Lindl. Curdinurka.

*Triraphis mollis* R. Br. William Creek, Irrapatana.

*Triodia aristata* J. M. Black. Half-way between Moorilyanna and Ernabella, Ernabella and rockhole 10 miles north.

*Eragrostis interrupta* (Lamk.) Beauv. var. *densiflora* Black. Ross Waterhole.

*E. pilosa* (L.) Beauv. Erliwanjawanja, Ross Waterhole, Hamilton Bore.

*E. concinna* Steud. Ross Waterhole.

*E. speciosa* Steud. Ross Waterhole.

*E. Brownii* Nees. William Creep, north of Irrapatana.

*E. minor* Host. William Creek, (Dec.).

*E. setifolia* Nees. Between Granite Downs and Lambinna, 20 miles west of Oodnadatta, north of Marree, Wangiana (erect), Ross Waterhole, Blood Creek.

*E. Dielsii* Pilger. North of Marree, Irrapatana (prostrate), Coward Springs, 15 miles north of Oodnadatta, Ross Waterhole.

*E.*, sp. nov. ? Ross Waterhole.

*Astrebla pectinata* F. v. M. 16 miles west and 15 miles north-west of Oodnadatta.

*Dactyloctenium radulans* (R. Br.) Beauv. Ross Waterhole.

Cyperaceae:—

*Cyperus distachyus* All. Bore at Marree (Dec.).

*C. squarrosus* (L.). Ross Waterhole.

*C. vaginatus* R. Br. Ernabella and rockhole 10 miles north, Hamilton Bore.

*C. difformis* L. Ross Waterhole.
*C. Iria* L. Ross Waterhole.
*C. rotundus* L. (apparently). Erliwanjawanja.
*C. bulbosus* Vahl. (probably). Rockhole 8 miles north of Ernabella.
*Scirpus cernuus* Vahl. Ross Waterhole.

JUNCACEAE:—
*Juncus polyanthemus* Buch. Ross Waterhole.

MORACEAE:—
*Ficus platypoda* A. Cunn. Erliwanjawanja.

URTICACEAE:—
*Parietaria debilis* G. Forst. Echo Hill between Moorilyanna and Ernabella, Erliwanjawanja, Ernabella.

PROTEACEAE:—
*Hakea lorea* R. Br. or *H. Ivoryi* Bailey. Ernabella, Erliwanjawanja.
*H. Ivoryi* Bailey. Ernabella (leaves, 1·5 mm. diameter), fruit curved at summit.
*Grevillea nematophylla* F. v. M. Ernabella, between Moorilyanna and Ernabella.

SANTALACEAE:—
*Santalum lanceolatum* R. Br. (broad-leafed form). Ernabella.

LORANTHACEAE:—
*Loranthus Preissii* Miq. On dead finish *(Acacia tetragonophylla)* at Anna Creek.
*L. Miquelii* Lehm. On bloodwood *(E. terminalis)*. Ernabella.
*L. Maidenii* Blakeley. Ross Waterhole.

POLYGONACEAE:—
*Rumex crystallinus* Lange. Beresford.
*Polygonum plebejum* R. Br. Gypsum Bore (50 miles west of Oodnadatta).

CHENOPODIACEAE:—
*Rhagodia spinescens* R. Br. Amongst rocks, Ernabella.
*Rh. spinescens* var. *deltophylla* F. v. M. Blood Creek.
*Rh. nutans* R. Br. Blood Creek.
*Chenopodium pumilio* R. Br. Rockhole 10 miles north of Ernabella, Ernabella.
*Ch. melanocarpum* Black. Ernabella, Erliwanjawanja.
*Ch. cristatum* F. v. M. Between Ernabella and Moorilyanna.
*Chenopodium Blackianum* Aellen *(Dysphania littoralis* R. Br.). Erliwanjawanja, Ross Waterhole, Hamilton Bore (sweet-scented).
*Atriplex nummularium* Lindl. Giant saltbush. 15 miles north-west of Oodnadatta, Ernabella on flat and amongst rocks, near Upsan Downs (Musgrave Ranges), half-way between Moorilyanna and Ernabella; aberrant (?) form, 10 miles north of Oodnadatta.
*A. angulatum* Benth. Curdimurka.
*A. velutinellum* F. v. M. Ross Waterhole.
*A. vesicarium* Hew. Bladder saltbush. Curdimurka, 20 miles and 50 miles (Gypsum Bore) west of Oodnadatta, between Moorilyanna and Ernabella (apparently bladderless form).
*A. Quinii* F. v. M. 20 miles and 50 miles (Gypsum Bore) west of Oodnadatta.
*A. fissivalve* F. v. M. 20 miles west of Oodnadatta.
*A. rhagodioides* F. v. M. Coward Springs.
*A. Muelleri* Benth. *(A. varium* Ewart and Davies, if this is more than a form). Hamilton Bore.

*A. lobativalve* F. v. M.. Macumba River.
*A. limbatum* Benth. William Creek, Ross Waterhole, Hamilton Bore.
*A. halimoides* Lindl. Curdimurka, Strangways Springs, Gypsum Bore (50 miles west of Oodnadatta).
*A. halimoides* var. *conduplicatum* F. v. M. et Tate. 15 miles north-west of Oodnadatta.
*A. spongiosum* F. v. M. Strangways Springs, Coward Springs, 20 miles west of Oodnadatta, half-way between Moorilyanna and Ernabella.
*Bassia uniflora* (R. Br.) F. v. M. 15 miles north-west of Oodnadatta, Hamilton Bore.
*B. bicornis* (Lindl.) F. v. M. Ross Waterhole.
*B. patenticuspis* R. H. Anders. Oodnadatta District or between here and Alice Springs.
*B. lanicuspis* F. v. M. 20 miles west of Oodnadatta.
*B. intricata* R. H. Anders. 20 miles west of Oodnadatta.
*B. divaricata* (R. Br.) F. v. M. 15 miles north-west of Oodnadatta.
*R. Blackiana* Ising. 20 miles west of Oodnadatta.
*Malacocera tricornis* (Benth.) R. H. Anders. 15 miles north-west of Oodnadatta.
*Kochia pyramidata* Benth. Alberrie Creek (22 miles north-west of Oodnadatta).
*K. eriantha* F. v. M. 20 miles west of Oodnadatta.
*K. Georgei* Diels. Near Upsan Downs (Musgrave Ranges).
*K. aphylla* R. Br. Cotton bush. 15 miles north-west of Oodnadatta.
*K. spongiocarpa* F. v. M. 20 miles west of Oodnadatta.
*K. ciliata* F. v. M. 15 miles north-west of Oodnadatta.
*K. brachyptera* F. v. M. (*Bassia brachyptera* R. H. Anders.). 20 miles west of Oodnadatta.
*Babbagia dipterocarpa* F. v. M. Strangways Springs.
*B.* sp. Rust on leaves. 20 miles west of Oodnadatta.
*Salsola Kali* L. Between Moorilyanna and Ernabella, Ross Waterhole.
*Thelkeldia inchoata* J. M. Black. Gypsum Bore (50 miles west of Oodnadatta).
*Arthrocnemium halocnemoides* Nees. Beresford, Coward Springs.
*A. halocnemoides* var. *pergranulatum* Black. Beresford, Coward Springs.

AMARANTACEAE:—

*Trichinium obovatum* Gaudich. Rockhole, 8 miles north of Ernabella, Abminga.
*T. exaltatum* (Nees) Benth. Abminga.
*T. helipteroides* F. v. M. var. *minor* J. M. Black. Abminga.
*T. nobile* Lindl. 20 miles west of Oodnadatta.
*T. corymbosum* Gaudich. Abminga.
*Amaranthus Mitchellii* Benth. Echo Hill, amongst granite rocks at Ernabella.
*Alternanthera angustifolia* R. Br. 22 miles west of Oodnadatta.

AIZOACEAE:—

*Tetragonia expansa* Murr. Gypsum Bore, S. Neales, 50 miles west of Oodnadatta.
*Gunnia septifraga* F. v. M. (?). South of William Creek.
*Gunniopsis zygophylloides* (F. v. M.) Maid. et Betche. 15 miles west of Oodnadatta, Alberrie, Curdimurka.
*G. quadrifida* (F. v. M.) Pax. William Creek.
*Glinus lotoides* Loefl. Beresford, Ross Waterhole, Oodnadatta.
*G. spergula* (L.) Pax. Ross Waterhole.

PORTULACACEAE:—

*Portulaca oleracea* L. Gypsum Bore, S. Neales, 50 miles west of Oodnadatta, Ross Waterhole (Macumba).

*Calandrinia volubilis* Benth. Ernabella and Rockhole 10 miles north.

*C.* sp. Between Echo Hill and Ernabella.

*C. ptychosperma* F. v. M. Ross Waterhole.

*C. stagnensis* J. M. Black. Ross Waterhole.

RANUNCULACEAE:—

*Ranunculus parviflorus* L. 22 miles west of Oodnadatta, Beresford.

CAPPARIDACEAE:—

*Polanisia viscosa* (L.) DC. Ernabella, Ross Waterhole.

CRUCIFERAE:—

*Blennodia trisecta* (F. v. M.) Benth. Wangianna.

*B. nasturtioides* (F. v. M.) Benth. 15 miles west of Oodnadatta.

*B. canescens* R. Br. Half-way between Moorilyanna and Ernabella, Irrapatana.

*Menkea sphaerocarpa* F. v. M. Half-way between Moorilyanna and Ernabella.

*Lepidium rotundum* DC. Near Lambinna, Curdimurka, Abminga.

*L. oxytrichum* Sprague. Ernabella, 15 and 22 miles north-west of Oodnadatta; S. Neales, 75 miles west of Oodnadatta; Echo Hill, between Moorilyanna and Ernabella; Gregg's Camp.

*L. Muelleri-Ferdinandi* Thell. Granite Downs, 100 miles west of Oodnadatta, Ross Waterhole.

*L. pseudo-ruderale* Thell. (apparently). Ernabella.

*Hutchinsia eremaea* J. M. Black. Wangianna, north of Marree.

*Stenopetalum velutinum* F. v. M. Lambinna, Ernabella.

*S. lineare* R. Br. var. *canescens* Benth. 15 miles north-west of Oodnadatta, Gregg's Camp (S. Neales, 75 miles west of Oodnadatta), between Moorilyanna and Ernabella.

*S. nutans* F. v. M. Abminga.

*S. sphaerocarpum* F. v. M. Ernabella.

CRASSULACEAE:—

*Crassula Sieberiana* (Schultes) Ostenf., Erliwanjawanja; rockhole 8 miles north of Ernabella.

PITTOSPORACEAE:—

*Pittosporum phillyreoides* DC. Half-way between Moorilyanna and Ernabella.

LEGUMINOSAE:—

*Acacia Victoriae* Benth. Ernabella, Hamilton Bore.

*A. ligulata* A. Cunn. Ernabella, Ross Waterhole (Macumba).

*A. strongylophylla* F. v. M. Rockholes, Ernabella.

*A. tetragonophylla* F. v. M. Ernabella.

*A. estrophiolata* F. v. M. Ernabella.

*A. coriacea* DC. Ross Waterhole.

*A. stenophylla* A. Cunn. Oodnadatta, Ross Waterhole.

*A. Cambagei* R. T. Baker (Gidya). Near Oodnadatta, Abminga.

*A. Oswaldii* F. v. M. S. Neales at 50 miles west of Oodnadatta, 15 miles north-west of Oodnadatta.

*A. Kempeana* F. v. M. Ernabella.

*A aneura* F. v. M. Erliwanjawanja, between Ernabella and Echo Hill, Lambinna.

*A. aneura* F. v. M. var. *latifolia* J. M. Black. Between Ernabella and Moorilyanna.

*A. brachystachya* Benth. Gypsum Bore (50 miles west of Oodnadatta), Erliwanjawanja.

*A. cyperophylla* F. v. M. (Red Mulga). Hamilton Bore.

*Cassia pleurocarpa* F. v. M. Hamilton Bore.

*C. Sturtii* R. Br. Blood Creek.

*C. artemesioides* Gaudich. Ernabella.

*Crotalaria Mitchellii* Benth. Hamilton Bore.

*C. dissitiflora* Benth. William Creek, Ross Waterhole, Hamilton Bore.

*Trigonella suavissima* Lindl. Wangianna, Beresford.

*Lotus australis* Andr. var. *parviflorus* Benth. 22 miles west of Oodnadatta.

(Near) *Indigofera Basedowii* Pritz. (*I. longibractea* J. M. Black). Ernabella.

*Psoralea patens* Lindl. Beresford, Irrapatana, 15 miles west of Oodnadatta, rockhole 10 miles north of Ernabella, Ross Waterhole.

*Swainsona villosa* J. M. Black. Between Echo Hill and Ernabella, Ernabella and rockhole 10 miles north, Erliwanjawanja.

*S. oroboides* F. v. M. Beresford.

*S. campylantha* F. v. M. Edward Creek, Wangianna.

*S. stipularis* F. v. M. (brick red or orange red flowers). Curdimurka.

*S. phacoides* Benth. Irrapatana.

*Aeschynomene indica* L. Ross Waterhole.

GERANIACEAE :—

*Erodium cygnorum* Nees. Ernabella to Echo Hill. Petals pink or blue. Some of the pink forms have upper leaves divided, glandular hairs and shorter awns.

OXALIDACEAE :—

*Oxalis corniculata* L. Ernabella.

ZYGOPHYLLACEAE :—

*Zygophyllum Billardieri* DC. Ernabella.

*Z. ammophilum* F. v. M. (probably). Amongst granite rocks, Ernabella.

*Z. iodocarpum* F. v. M. Gypsum Bore (50 miles west of Oodnadatta).

*Z. Howitii* F. v. M. Irrapatana.

*Z.*, sp. Ross Waterhole.

*Tribulus terrestris* L. Ernabella.

EUPHORBIACEAE :—

*Euphorbia australis* Boiss. Amongst granite rocks, Ernabella.

*E. Drummondii* Boiss. Ernabella, Blood Creek.

*E. eremophila* A. Cunn. Ernabella.

*Phyllanthus lacunarius* F. v. M. Hamilton Bore.

SAPINDACEAE :—

*Dodonaea petiolaris* F. v. M. Ernabella.

MALVACEAE :—

*Malvastrum spicatum* (L.) A. Gray. Blood Creek.

*Plagianthus glomeratus* (Hook.) Benth. Coward Springs.

*Sida corrugata* Lindl. var. *trichopoda* Benth. Edward Creek.

*S. intricata* F. v. M. Oodnadatta, Ross Waterhole, Hamilton Bore.

*S. virgata* Hook. var. *phaeotricha* (F. v. M.) Benth. Erliwanjawanja, rockhole 10 miles north of Ernabella.

*Abutilon leucopetalum* F. v. M. Ernabella. 20 miles west of Oodnadatta.

*A. otocarpum* F. v. M. Hamilton Bore.

*A. Fraseri* Hook. Edward Creek, Anna Creek.
*A. halophilum* F. v. M. 20 miles west of Oodnadatta.
*Hibiscus brachychlaenus* F. v. M. Ernabella.
*H. Sturtii* Hook. (cleistogamous form). Ernabella, and rockhole 8 miles north.
*Gossypium Sturtii* F. v. M. Amongst rocks, Ernabella.

FRANKENIACEAE :—

*Frankenia planifolia* Sprague et Summerhayes. 16 and 22 miles west of Oodnadatta.
*F. flabellata* Sprague. 22 miles west of Oodnadatta.
*F. serpyllifolia* Lindl. 15 miles north-west of Oodnadatta, Hamilton Bore.
*F. latior* Summerhayes. Abminga.

THYMELAEACEAE :—

*Pimelea microcephala* R. Br. 20 miles west of Oodnadatta, Gypsum Bore (50 miles west of Oodnadatta).
*P. simplex* F. v. M. 5 miles north of Marree, 20 miles west of Oodnadatta.

LYTHRACEAE :—

*Ammania multiflora* Roxb. Ross Waterhole.

MYRTACEAE :—

*Melaleuca linophylla* F. v. M. 10 miles north of Ernabella.
*M. monticola* J. M. Black. Ernabella, and 16 miles south-west.
*M. glomerata* F. v. M. 16 miles south-west of Ernabella.
*Eucalyptus intertexta* R. T. Baker. (A tall box gum with "stocking" base.) On watercourse 16 miles south-west of Ernabella, Oodnadatta.
*E. bicolor* A. Cunn. var. *xanthophylla* Blakeley. A spreading tree with rough bark hanging in shreds and clean branches. In watercourse, Ernabella.
*E. microtheca* Maiden. Gypsum Bore (50 miles west of Oodnadatta).
*E. oleosa* F. v. M. Arkaringa Creek, 85 miles west of Oodnadatta, half-way between Moorilyanna and Ernabella, Erliwanjawanja.
*E. rostrata* Schl. Ernabella, Ross Waterhole, Hamilton Bore.
*E. terminalis* F. v. M. or *E. dichromophloia.* Between Moorilyanna and Ernabella. "I think these are a small-fruited form of *E. terminalis,* as shown in Maiden's illustration. *E. dichromophloia* has small, very smooth fruits with thin walls" (J. M. B.).

HALORRHAGIDACEAE :—

*Halorrhagis heterophylla* Brongn. Rockhole 10 miles north of Ernabella, Hamilton Bore.
*Myriophyllum verrucosum* Lindl. Erliwanjawanja, Ross Waterhole, Hamilton Bore.

UMBELLIFERAE :—

*Hydrocotyle trachycarpa* F. v. M. Ernabella and rockhole 8 miles north.
*Didiscus,* probably *D. glaucifolius* F. v. M. Rockhole 8 miles north of Ernabella (probably), 40 miles north of Beresford.
*Daucus glochidiatus* (Labill.) Fischer, Mey et Ave-Lall. Ernabella and rockhole 8 miles north.

PRIMULACEAE :—

*Samolus repens* (Forst.) Pers. Ernabella (flowers pink).

CONVOLVULACEAE :—

*Ipomoea Muelleri* Benth. Ross Waterhole.
*Convolvulus erubescens* Sims. Rockhole 10 miles north of Ernabella.

ASCLEPIADACEAE :—

*Sarcostemma australe* R. Br. Used for sores by natives and whites. Ernabella.

CONVOLVULACEAE :—

*Convolvulus erubescens* Sims.

BORRAGINACEAE :—

*Heliotropium europaeum* L. Gypsum Bore (50 miles west of Oodnadatta).
*H. asperrimum* R. Br. Ernabella.
Near *H. apiculatum* Mey. Ross Waterhole.
*Trichodesma zeylanicum* (Burm.) R. Br. Erliwanjawanja.
*Cynoglossum australe* R. Br. var. *Drummondii* Brand. Ernabella.

VERBENACEAE :—

*Verbena officinalis* L. Ross Waterhole.

LABIATAE :—

*Teucrium racemosum* R. Br. Ross Waterhole.
*Plectranthus parviflorus* Henckel. Rockhole 8 miles north of Ernabella.
*Prostanthera striatiflora* F. v. M. Erliwanjawanja.

SOLANACEAE :—

*Solanum petrophilum* F. v. M. (Yellow berries.) Amongst rocks, Ernabella; rockhole 10 miles north of Ernabella.
*S. ellipticum* R. Br. Among rocks at Ernabella, Abminga.
*Nicotiana excelsior* J. M. Black. Near Ernabella.
*N. Gossei* Domin. Erliwanjawanja.
*Nicotiana* near *N. velutina* Wheeler. 15 miles north west of Oodnadatta; S. Neales, 50 miles west of Oodnadatta; between Ernabella and Echo Hill; Ernabella.
*Duboisia Hopwoodii* F. v. M. 20 miles south of Ernabella.

SEROPHULARIACEAE :—

*Stemodia viscosa* Roxb. Rockholes 8 and 10 miles north of Ernabella.
*Limosella Curdieana* F. v. M. Beresford.
*Glossostigma spathulatum* Wight et Arn. Ross Waterhole.

BIGNONIACEAE :—

*Tecoma doratoxylon* J. M. Black. Ernabella.

ACANTHACEAE :—

*Justicia procumbens* L. Ernabella.

MYOPORACEAE :—

*Eremophila Sturtii* R. Br. Upsan Downs Station (Musgrave Ranges).
*E. Latrobei* F. v. M. Echo Hill, between Moorilyanna and Ernabella.
*E. longifolia* (R. Br.) F. v. M. Ernabella.
*E. rotundifolia* F. v. M. S. Neales, 30 miles west of Oodnadatta.
*E. Freelingii* F. v. M. 20 miles west of Oodnadatta, Gregg's Camp (S. Neales, 75 miles west of Oodnadatta), Echo Hill (between Moorilyanna and Ernabella), Ernabella, Abminga.
*E. Duttonii* F. v. M. Arkaringa Creek (90 miles west of Oodnadatta).
*E. serrulata* (A. Cunn.) Druce. Ernabella.
*E. calycina* S. Moore. Between Moorilyanna and Ernabella.
*E. neglecta* J. M. Black. S. Neales (50 miles west of Oodnadatta).
*E. MacDonnellii* F. v. M. Ross Waterhole.
*E. MacDonnellii* var. *glabriuscula* J. M. Black. Hamilton Bore.

PLANTAGINACEAE :—

*Plantago varia* R. Br. 15 miles west of Oodnadatta, Gypsum Bore (50 miles west), and between there and Welbourn Hill.

RUBIACEAE :—

*Synaptantha tillaeacea* (F. v. M.) Hook. f. Ross Waterhole, Abminga.

*Plectronia latifolia* (F. v. M.) Benth. et Hook. (?) Near Lambinna.

CUCURBITACEAE :—

*Melothria maderaspatana* (L.) Cogn. Ernabella.

CAMPANULACEAE :—

*Wahlenbergia*, sp. (flowers white or blue, sometimes on the same plant). Ross Waterhole.

*Isotoma petraea* F. v. M. Ernabella.

GOODENIACEAE :—

*Goodenia lunata* J. M. Black. Ross Waterhole.

*G. subintegra* F. v. M. 15 miles west of Oodnadatta, Gypsum Bore (50 miles west), Hamilton Bore.

*Scaevola depauperata* R. Br. (?). Hamilton Bore.

*S. ovalifolia* R. Br. Hamilton Bore.

COMPOSITAE :—

*Brachycome pachyptera* Turcz. 20 miles west of Oodnadatta.

*B. ciliaris* (Labill.) Less. Lambinna, Beresford.

*B. ciliaris* var. *lanuginosa* (Steetz.) Benth. Beresford, Anna Creek.

*Minuria Cunninghamii* (DC.) Benth. (?). Curdimurka.

*M. integerrima* (DC.) Benth. Beresford.

*M. denticulata* (DC.) Benth. Gypsum Bore (50 miles west of Oodnadatta), Abminga, Wangianna, Blood Creek, Edward Creek.

*M. annua* Tate. Curdimurka, (south of Quorn).

*Calotis cymbacantha* F. v. M. Between Moorilyanna and Ernabella.

*C. erinacea* Steetz. Hamilton Bore.

*C. multicaulis* (Turcz.) J. M. Black. 15 miles north-west and 50 miles west (S. Neales) of Oodnadatta, between Moorilyanna and Ernabella, Abminga.

*C. porphyrocephala* F. v. M. Ross Waterhole.

*C. hispidula* F. v. M. 20 miles west of Oodnadatta, half-way between Moorilyanna and Ernabella, north of Marree.

*Erigeron sessilifolius* F. v. M. Ross Waterhole.

*Podocoma cuneifolia* R. Br. Anna Creek.

*P. nana* Ewart et White. Half-way between Moorilyanna and Ernabella.

*Wedelia verbesinoides* (F. v. M. herb.) Benth. Ernabella.

*Siegesbeckia orientalis* L. Echo Hill, Ernabella, and rockhole 10 miles north of Ernabella.

*Dimorphocoma minutula* F. v. M. Curdimurka.

*Centipeda Cunninghamii* (DC.) A. Br. et Aschers. Beresford, Ross Waterhole.

*C. thespidioides* F. v. M. 20 miles west of Oodnadatta.

*Senecio Gregorii* F. v. M. 20 miles west of Oodnadatta.

*S. brachyglossus* F. v. M. 15 miles, 50 miles (Gypsum Bore), and 70 miles. west of Oodnadatta.

*S. magnificus* F. v. M. (?). Rockhole 8 miles north of Ernabella.

*S. Cunninghamii* DC. Quorn.

*Pluchea dentex* R. Br. Ernabella.

*P. rubelliflora* (F. v. M.) J. M. Black. Ross Waterhole.

*Pterigeron liatroides* (Turcz.) Benth. Ross Waterhole, Hamilton Bore.

*Pt. cylindriceps* J. M. Black. Blood Creek.
*Epaltes Cunninghamii* (Hook.) Benth. Ross Waterhole, Hamilton Bore.
*E. australis* Less. Ross Waterhole.
*Pterocaulon glandulosum* (F. v. M.) Benth. et Hook. var. *velutinum* Ewart et Davies. Rockhole 8 miles north of Ernabella.
*Pt. sphacelatum* (Labill.) Benth. et Hook. Ross Waterhole.
*Gnaphalium luteo-album* L. Irrapatana, Ross Waterhole.
*Gn. japonicum* Thunb. Ernabella.
*Gn. indutum* Hook. f. Ross Waterhole.
*Helipterum floribundum* DC. 15 miles north-west of Oodnadatta, between Echo Hill and Ernabella.
*H. albicans* (A. Cunn.) DC. Wangianna.
*H. stipitatum* F. v. M. Lambinna.
*H. Fitzgibbonii* F. v. M. Lambinna.
*H. microglossum* (F. v. M.) Tate. Beresford, Anna Creek, 15 miles west and 23 miles north-west of Oodnadatta, between Granite Downs and Lambinna.
*H. strictum* (Lindl.) Benth. Beresford; 16 miles, 22 miles, and 75 miles (Gregg's Camp on S. Neales) west of Oodnadatta, Abminga.
*H. moschatum* (A. Cunn.) Benth. Between Echo Hill and Ernabella.
*H. uniflorum* J. M. Black. North of Marree, Beresford, 20 miles west of Oodnadatta.
*H. Tietkensii* F. v. M. S. Neales (50 miles west of Oodnadatta), half-way between Moorilyanna and Ernabella, rockhole 10 miles north of Ernabella.
*H. Charsleyae* F. v. M. 22 miles and 75 miles (Gregg's Camp) west of Oodnadatta, Ross Waterhole, Abminga (probably).
*Ixiolaena leptolepis* (DC.) Benth. Spreading, 18 in. high. Curdmiurka, 10 miles west and 15 miles west of Oodnadatta, Blood Creek.
*Helichrysum Cassinianum* Gaudich. Lambinna.
*H. roseum* (Lindl.) Druce. Between Moorilyanna and Ernabella.
*H. Ayersii* F. v. M. Granite Downs (150 miles west of Oodnadatta).
*H. bracteatum* (Vent.) Andrews. Ernabella.
*H. apiculatum* (Labill.) DC. Ernabella (or *H. ambiguum*), Hamilton Bore.
*H. ambiguum* Turcz. Strong, unpleasant smell. Ernabella, and rockhole 8 miles north.
*H. podolepideum* F. v. M. Anna Creek.
*Rutidosis helichrysoides* DC. Ilbunga, north of Oodnadatta, Blood Creek.
*Podolepis canescens* A. Cunn. Lambinna.
*P. capillaris* (Steetz.) Diels. Between Moorilyanna and Ernabella, Ross Waterhole.
*Myriocephalus rhizocephalus* (DC.) Benth. var. *pluriflora* J. M. Black. Beresford.
*M. Stuartii* (F. v. M. et Sond.) Benth. Between Ernabella and Echo Hill, rockhole 10 miles north of Ernabella.
*M. Rudallii* (F. v. M.) Benth. Ross Waterhole.
*Angianthus pusillus* Benth. Between Echo Hill and Ernabella.
*Gnephosis cyathopappa* Benth. William Creek, Abminga.
*Calocephalus multiflorus* (Turcz.) Benth. Ross Waterhole.
*Craspedia pleiocephala* F. v. M. Curdimurka.
*Basedowia tenerrima* (F. v. M.) J. M. Black. Rockhole 8 miles north of Ernabella.

INTRODUCED.

*Sonchus oleraceus* L. Waterholes near Ernabella.
*S. asper* Hill. Waterhole near Ernabella.

# SOUTH AUSTRALIAN CAINOZOIC BRYOZOA. - PART I.

*BY LEO. W. STACH, B.SC.*

**Summary**

At the instigation of Prof. W. Howchin a series of studies on the Cainozoic Bryozoa of South Australia has been commenced. This first contribution deals with material from two horizons in the Cowandilla Bore, *vis.,* 485-507 feet (1) and 520-550 feet (2), and three horizons in the Glanville Bore, *vis.,* 375-400 feet (3), 405-450 feet (4) and 445-490 feet (5) *(vide* Howchin, 1935 and 1936).

The material has yielded three new species and provides interesting stratigraphic and distributional data, particularly in connection with the species *Thalamoporella gracilis* Maplestone, 1900, and *Cellaria variabilis* ( Busk, 1884) . The type material has been deposited with the South Australian Museum.[1]

# SOUTH AUSTRALIAN CAINOZOIC BRYOZOA.—PART I.

By Leo. W. Stach, B.Sc.
(Howitt and MacBain Research Scholar in Zoology, University of Melbourne.)
(Communicated by Prof. Walter Howchin.)

[Read September 10, 1936.]

Plate XV.

## Introduction.

At the instigation of Prof. W. Howchin a series of studies on the Cainozoic Bryozoa of South Australia has been commenced. This first contribution deals with material from two horizons in the Cowandilla Bore, *viz.*, 485-507 feet (1) and 520-550 feet (2), and three horizons in the Glanville Bore, *viz.*, 375-400 feet (3), 405-450 feet (4) and 445-490 feet (5) (*vide* Howchin, 1935 and 1936).

The material has yielded three new species and provides interesting stratigraphic and distributional data, particularly in connection with the species *Thalamoporella gracilis* Maplestone, 1900, and *Cellaria variabilis* (Busk, 1884). The type material has been deposited with the South Australian Museum.[1]

## List of Species.

*Selenaria maculata* (Busk, 1852). 1, 2, 3.
*Thalamoporella gracilis* Maplestone, 1900. 1, 2, 4, 5.
*Thalamoporella howchini*, sp. nov. 1, 2.
*Cellaria australis* Macgillivray, 1880. 1, 2, 3, 4, 5.
*Cellaria variabilis* (Busk, 1884). 2, 3, 4, 5.
*Caberea grandis* Hincks, 1881. 2.
*Porina gracilis* (Lamarck, 1816). 2, 5.
*Tubucellaria cereoides gracilis* Canu and Bassler, 1929. 4, 5.
*Iodictyum* cf. *phoeniceum* (Busk, 1854). 2, 3, 4.
*Sertella porcellana* (Macgillivray, 1869). 1, 2, 3, 4, 5.
*Adeonellopsis australis* Macgillivray, 1886. 1, 2, 3.
*Parmularia obliqua* (Macgillivray, 1869). 1.
*Phylactellina cowandillensis*, gen. et sp. nov. 2.
*Conescharellina angulopora* (Woods, 1880). 4, 5.
*Conescharellina crassa* (Woods, 1880). 4, 5.
*Hornera foliacea* Macgillivray, 1869. 1, 2, 3, 4, 5.
*Hornera robusta* Macgillivray, 1883. 4, 5.
*Idmonea australis* Macgillivray, 1882. 2, 3, 4, 5.
*Idmonea macgillivrayi*, sp. nov. 4, 5.

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(1) The list of references at the conclusion of the paper contains only those references which are mentioned in the text and those which occur more than once in the synonymies of the species, these latter being referred to in the synonymies only by author and date, thus: Livingstone, 1928, p. 111. Where a reference occurs in the synonymy only once, an abbreviated reference is given in the synonymy, thus: Maplestone, 1900, Proc. Roy. Soc. Vic., n.s., **vol. xiii,** (1) p. 6.

# SYSTEMATIC DESCRIPTION

## Family MICROPORIDAE Hincks, 1880.

### Subfamily MICROPORINAE Hincks, 1880.

### Genus Selenaria Busk, 1854.

### Selenaria maculata (Busk, 1852).

*Lunulites maculata* Busk, 1852, appendix to "Voyage of the *Rattlesnake*" by J. Macgillivray, i, pl. i, figs. 15, 16.

*Selenaria maculata* (Busk), Waters 1885, p. 309. Maplestone, 1904, *a*, p. 208; *idem*, 1904, *b*, p. 198; *idem*, 1909, p. 268. Waters, 1921, Journ. Linn. Soc. Zool., **vol. xxxiv**, p. 417, pl. xxix, fig. 8, pl. xxx, figs. 13-15. Chapman, 1928, p. 148. Stach, 1935, *a*, p. 341.

*Observations*—This form occurs in the Lower Miocene and Lower Pliocene of Victoria, and is found at the present day along the continental shelf of eastern and southern Australia (for detailed distribution, *vide* Stach, 1935, *a)*.

## Family THALAMOPORELLIDAE Levinsen, 1902.

### Genus Thalamoporella Hincks, 1887.

### Thalamoporella gracilis Maplestone, 1900.

(Text fig. 2.)

*Thalamoporella gracilis* Maplestone, 1900, Proc. Roy. Soc. Vic., n.s., **vol. xiii**, (1), p. 6, pl. ii, fig. 13; *idem*, 1904, *b*, p. 199.

*Observations*—This species is unique in the genus in that the avicularium is directed proximally. The zooecial characters of the present specimens are identical with those of Maplestone's form, but the zoarium appears to have been bilaminate at the present locality. The zooecia of this species are very like those of *Thalamoporella elongata* Canu and Bassler, 1935 (*non* Canu, 1917, p. 140) from the Lower Miocene of Bairnsdale, but as these authors do not mention or figure the avicularia, their conspecificity cannot be proved.

*Distribution*—Lower Pliocene: Jemmy's Point, Lakes Entrance (Victoria).

### **Thalamoporella howchini,** sp. nov.

(Pl. xv, fig. 2.)

**Description**—Zoarium bilaminate. Avicularia arranged in longitudinal series between the vertical rows of zooecia. Zooecia rectangular in outline, less than twice as long as broad, and separated by thick salient ridges. Aperture higher than broad, oval in outline and with inconspicuous hinge teeth; height of aperture equals less than one-third length of zooecium. The adoral areas bear large projecting acropetalous spines of which the diameter equals half the height of the aperture. The two opesiules are unequal in size, the larger being transversely oval in plan and descending to the basal wall, while the smaller is longitudinally oval and appears to reach the lateral wall. The cryptocyst is much depressed below the level of the aperture and is perforated by about twenty fine circular pores. The avicularia are elongate rectangular in outline and equal in length about one and a half times that of the zooecia, their width being about half that of a zooecium. The distal end of each avicularium is acute and slightly recurved, while a well-developed broad cross-bar occurs proximal to the middle line.

*Dimensions*—Zooecium, length 0·58 mm., breadth 0·38; aperture, height 0·25, breadth 0·20; spine, diameter, 0·09; avicularium, length 0·85, breadth 0·22.

*Type Material*—Holotype: South Aust. Mus. Coll., No. L 2. Bilaminate specimen from 485-507 feet in the Cowandilla Bore. Paratype: South Aust. Mus. Coll., No. L 3. A fragment from 520-550 feet in the Cowandilla Bore.

*Observations*—In the form of the zooecia, this striking species approaches most closely to the Madagascan *Thalamoporella harmeri* Levinsen, 1909, from which it differs in the greater proportionate width of the zooecia and the much greater proportionate length of the avicularia. This species is readily distinguished by the arrangement of the avicularia, the short zooecia and the well-developed spines of the adoral area. A specimen referable to this species (paratype) was found at 520-550 feet, but although possessing the characteristic large avicularia with cross-bar, the adoral areas were scarcely developed and the acropetaous spines were absent. This suggests that the latter character is variable within species and probably conditioned by local environmental factors.

### Family CELLARIIDAE Hincks, 1880.

### Genus Cellaria Ellis and Solander, 1786.

### Cellaria australis Macgillivray, 1880.

(Pl. xv, fig. 3.)

*Cellaria fistulosa* var. *australis* Macgillivray, 1880, dec. v, p. 48, pl. xlix, fig. 1.
*Salicornaria clavata* Busk, 1884, p. 88, pl. xii, fig. 8.
*Cellaria australis* Macgillivray, 1889, p. 26; *idem*, 1895, p. 29, pl. iii, fig. 19. Maplestone, 1904, *b*, p. 193; *idem*, 1909, p. 267. Chapman, 1928, p. 147. Livingstone, 1928, p. 115. Stach, 1935, a, p. 342; *idem*, 1936, Proc. Roy. Soc. Vict., n.s., **vol. xlix**, (1), p. 62.

*Observations*—This species occurs fossil from Upper Oligocene to Lower Pliocene in Victoria and is commonly dredged off the coast from New South Wales around to South Australia (for detailed distribution, *vide* Stach, 1935, *a*).

### Cellaria variabilis (Busk, 1884).

(Pl. xv, fig. 1.)

*Salicornaria variabilis* Busk, 1884, p. 89, text fig. 7, pl. xii, figs. 3, 9.

*Observations*—This species has been recorded only in the vicinity of Kerguelen Island (southern Indian Ocean), from 25 to 70 fathoms. The present specimens agree in all essential characters with Busk's figures. This form is allied to *Cellaria contigua* Macgillivray, 1895, var. *corioensis* Maplestone, 1901, in the type of avicularium and general form of the zooecia, but differs from it in having a shorter semi-circular aperture and a tendency to the development of rhomboid zooecia.

### Family SCRUPOCELLARIIDAE Levinsen, 1909.

### Genus Caberea Lamouroux, 1816.

### Caberea grandis Hincks, 1881.

*Caberea grandis* Hincks, 1881, Ann. Mag. Nat. Hist., ser. 5, **vol. viii**, p. 2, pl. iii, figs. 4, 4 *a-b*. Waters, 1887, p. 90. Macgillivray, 1895, p. 25, pl. iii, fig. 9. Maplestone, 1904, *b*, p. 192; *idem*, 1909, p. 267. Livingstone, 1927, Rec. Austr. Mus., **vol. xvi**, (1), p. 53. Chapman, 1928, p. 147. Stach, 1935, *a*, p. 342.

*Observations*—This species occurs in the Lower Miocene and Lower Pliocene of Victoria, and has been dredged at moderate depths (10 to 40 fathoms) in Torres Straits (?) and along the eastern and southern coasts of Australia.

### Family PORINIDAE d'Orbigny, 1852.

### Genus Porina d'Orbigny, 1852.

### Porina gracilis (Lamarck, 1816).

*Eschara gracilis* Lamarck, 1816, Hist. Nat. An. sans Vert., **vol. i**, p. 176. Milne-Edwards, 1837, Ann. Sci. Nat., ser. 2, **vol. vi**, p. 28, pl. ii, fig. 2. Macgillivray, 1880, dec. v, p. 40, pl. xlviii, fig. 3. Busk, 1884, p. 141, pl. xxi, fig. 6.

*Porina gracilis* (Lamarck), d'Orbigny, 1852, Pal. Franc. Terr. Crét., **vol. v,** p. 434. Macgillivray, 1895, p. 103, pl. xiv, figs. 21, 22. Bassler, 1935, Fossilium Catalogus, pt. 67, p. 175.

*Porina dieffenbachiana* Stoliczka, 1864, Reise der "Novara," geol. Theil, **vol. i,** (2), p. 135.

*Eschara buskii* Woods, 1876, Proc. Roy. Soc. N.S.W., **vol. x,** p. 149, figs. 16, 17.

*Porina coronata* Waters (? *non* Reuss, 1847), 1881, p. 333, pl. xvi, fig. 57; *idem*, 1885, p. 297.

*Porina gracilis* var. *dieffenbachiana* Stoliczka, Macgillivray, 1895, p. 103.

*Haswellia coronata* Levinsen (? *non* Reuss), 1909, Morph. Syst. Stud. Cheil. Bryozoa, p. 299, pl. xvi, fig. 1.

*Acropora gracilis* (Lamarck), Canu, 1913, p. 137. Canu and Bassler, 1920, U.S. Nat. Mus. Bull., No. 106, p. 318, figs. 90 A-E.

*Haswellina coronata* Livingstone (? *non* Reuss), 1928, p. 120.

*Observations*— The synonymy listed above refers only to the forms recorded from southern Australia and New Zealand (fossil and recent). The Australian form has been regarded as synonymous with *Porina coronata* (Reuss, 1847) from the Lower Oligocene (Priabonian) of Italy by Waters (1881) and others, while Canu (1913) has listed several points of distinction between the two forms. Concerning the latter, it may be remarked that these distinctions could be accounted for by varying degrees of abrasion and normal variation within the species. A critical examination of a large series of specimens is necessary before any conclusions may be drawn.

Further complication in the synonymy, caused by confusing *"Myriozoum australiense"* Haswell, 1880, with this form, was ably dispelled by Busk (1884) and was confirmed by comparison with topotypes from Holborn Island at 20 fathoms.

This species occurs in the Miocene of New Zealand and Victoria and is commonly dredged off the Victorian and South Australian coasts.

## Family TUBUCELLARIIDAE Busk, 1884.

### Genus Tubucellaria d'Orbigny, 1852.

### Tubucellaria cereoides gracilis Canu and Bassler, 1929.

*Tubucellaria cereoides gracilis* Canu and Bassler, 1929, p. 355, pl. xliv, figs. 1, 2. Stach, 1935, *a,* p. 344, pl. xii, fig. 7.

*Observations* —This form appears in the Victorian Lower Pliocene and occurs in the western Pacific and along the south coast of Australia.

## Family RETEPORIDAE Smitt, 1867.

### Genus Iodictyum Harmer, 1933.

### Iodictyum cf. phoeniceum (Busk, 1854).

*Retepora phoenicea* Busk, 1854, Brit. Mus. Cat., **vol. ii,** p. 94, pl. cxxi, figs. **1,** 2. Macgillivray, 1889, p. 29. Livingstone, 1928, p. 117; *idem,* 1929, Vidensk. Medd. fra Dansk Naturh. Foren., **vol. lxxxvii,** p. 91.

*Iodictyum phoeniceum* (Busk), Harmer, 1933, Proc. Zool. Soc., London, p. 625; *idem,* 1934, p. 541. Stach, 1935, *b,* p. 141 (?).

(Not *Retepora phoenicea* Waters, 1887, p. 197, pl. vi, figs. 15, 20 = *I. willeyi* Harmer, 1934; Kirkpatrick, 1890, Sci. Proc. Roy. Dublin Soc., **vol. vi,** (10), p. 612, = *I. sanguineum* (Ortmann, 1890).

(Not *Schizellozoon pheniceum* Canu and Bassler, 1929, p. 370, pl. xlviii, figs. 1-5 = *I. projectum* Harmer, 1934).

*Observations*—Three specimens are doubtfully referred to this species, their preservation not permitting certain identification. They are typical *Iodictyum*, but the fenestration of the fragments is more open than in Recent specimens of *I. phoeniceum*. The latter is recorded with certainty from Victoria and South Australia at moderate depths, but Queensland records are dubious. The author (1935, *b*) doubtfully referred a fragment of a zoarium from Green Island (off Cairns) to this species, but better material is necessary to check this. This is the initial fossil record of the genus.

### Genus SERTELLA Jullien, 1903.

#### SERTELLA PORCELLANA (Macgillivray, 1869).

(Pl. xv, fig. 4.)

*Retepora porcellana* Macgillivray, 1869, p. 140; *idem*, 1885, dec. x, p. 15, pl. xcv, figs. 1-6; *idem*, 1895, p. 115, pl. xv, fig. 15. Stach, 1935, *a*, p. 344.

*Observations*—This species has been recorded from the Lower Miocene and Lower Pliocene of Victoria and is fairly common at the present day along the Victorian coast. The recent work of Harmer (1934) on Reteporidae necessitates the above generic change.

## Family ADEONIDAE Jullien, 1903.

### Genus ADEONELLOPSIS Macgillivray, 1886.

#### ADEONELLOPSIS AUSTRALIS Macgillivray, 1886.

(Pl. xv, fig. 5.)

*Adeonellopsis australis* Macgillivray, 1886, Trans. Proc. Roy. Soc. Vict., **vol. xxii**, p. 135, pl. ii, figs. 2, 3. Stach, 1935, *a*, p. 345.

*Observations*—This species occurs in the Victorian Lower Pliocene and is common in dredgings off the Victorian and South Australian coasts.

## Family PARMULARIIDAE Maplestone, 1912.

### Genus PARMULARIA Macgillivray, 1887.

#### PARMULARIA OBLIQUA (Macgillivray, 1869).

*Eschara obliqua* Macgillivray, 1869, p. 137.

*Parmularia obliqua* (Macgillivray), Livingstone, 1924, p. 190, pl. xxiii, figs. 1, 2, pl. xxv, fig. 1, pl. xxvi, text fig. 1; *idem*, 1928, p. 119. Stach, 1935, *a*, p. 343, pl. xii, fig. 5.

*Observations*—This species occurs abundantly in most of the deeper water dredgings off the Victorian and South Australian coasts and has been recorded from the Lower Pliocene of eastern (as *Schizoporella flabellata* Maplestone, 1902, p. 68) and western Victoria.

## Family PHYLACTELLIDAE Canu and Bassler, 1917.

### Genus **Phylactellina,** gen. nov.

#### Type: **Phylactellina cowandillensis,** sp. nov.

*Description*—Aperture with well-developed lyrule and strongly salient peristome, producing a subcircular peristomice with a somewhat sinuate margin. Upwardly directed avicularia occur on the outer proximal slopes of the peristome. The ovicell is globular, cribriform and opens into the peristome; it rests on the proximal portion of the distal zooecium.

*Observations*—The strongly salient peristome, cribriform ovicell opening into the peristome and the aperture with lyrule place this form in Phylactellidae. From *Phylactella* Hincks, 1880, it differs in the presence of large avicularia on the peristome.

**Phylactellina cowandillensis,** sp. nov.

(Text figs. 1, 1 *a-c.*)

*Description*—Zoarium massive, eschariform. Zooecia elongate-pyriform in outline, attenuated proximally and separated by salient narrow ridges. The frontal is granular and perforated by fine pores, the marginal areolae being deeply set and widely spaced. Aperture subcircular with a well-developed lyrule. The salient peristome has a broad base and bears a large acute avicularium directed upward on its outer proximal slope and somewhat to one side. Occasionally a smaller acute avicularium also occurs laterally on the peristome. Spatulate avicularia occur rarely on the frontal. The ovicells are globular, wider than high and bear on their summits a circular cribriform area.

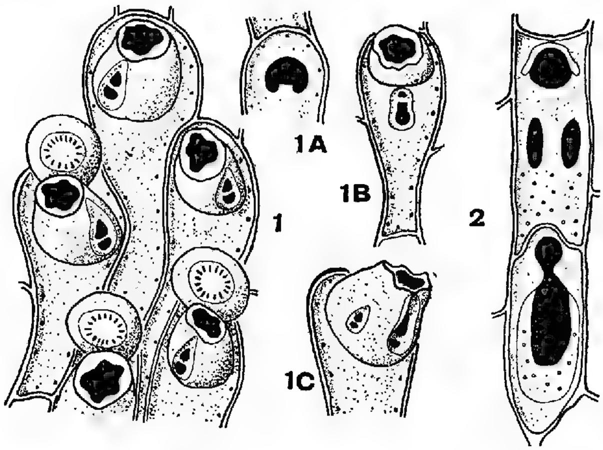


Fig. 1. Fig. 2.

Fig. 1. *Phylactellina cowandillensis*, sp. nov. Cowandilla Bore at 520 to 550 feet. Holotype, South Aust. Mus. Coll., No. L4. Portion of zoarium showing ovicelled zooecia and zooecial detail. Fig. 1 *a*. Zooecium with abraded peristome, showing form of aperture. Fig. 1 *b*. Zooecium with spatulate frontal avicularium. Fig. 1 *c*. Zooecium seen partly in lateral view, showing an additional acute avicularium on the peristome.

Fig. 2.

Fig. 2. *Thalamoporella gracilis* Maplestone, 1900. Cowandilla Bore at 520 to 550 feet. Plesiotype, South Aust. Mus. Coll. No. L8. Zooecium and proximally directed avicularium.

*Dimensions*—Zooecium, length 0·85 mm., width 0·24; peristome, basal diameter 0·23; peristomice, diameter 0·13; aperture, diameter 0·12; ovicell, width 0·22, height 0·20.

*Type Material*—Holotype: South Aust. Mus. Coll., No. L4. Specimen showing ovicells, from 520 to 550 feet in the Cowandilla Bore.

*Distribution*—Cowandilla Bore at 520 to 550 feet.

*Observations*—The holotype shows avicularia on the peristomes of nearly every zooecium, but other specimens from the same material have few peristomes

with avicularia, the zooecia being also often proportionately broader. (Paratype, South Aust. Mus. Coll., No. L 5.)

### Family CONESCHARELLINIDAE Levinsen, 1909.

#### Genus Conescharellina d'Orbigny, 1852.

##### Conescharellina angulopora (Woods, 1880).

*Lunulites angulopora* Woods, 1880, p. 7, pl. i, figs. 3 *a-c*.

*Conescharellina angulopora* (Woods), Livingstone, 1924, p. 205; *idem*, 1928, p. 121.

*Observations*—This species has been known previously as a recent form from the coasts of south-eastern Australia. Macgillivray's doubtful record of its occurrence in the Lower Miocene of Victoria (1895) may be disregarded.

##### Conescharellina crassa (Woods, 1880).

*Lunulites (Cupularia) crassa* Woods, 1880, p. 5, pl. i, fig. 1.

*Conescharellina crassa* (Woods), Livingstone, 1924, p. 212.

*Observations*—The occurrence of this form is similar to that of *C. angulopora*.

### Family HORNERIDAE Gregory, 1899.

#### Genus Hornera Lamouroux, 1821.

##### Hornera foliacea Macgillivray, 1869.

*Hornera foliacea* Macgillivray, 1869, p. 142 . Busk, 1887, p. 17. Macgillivray, 1895, p. 127, pl. xix, fig. 1.

*Observations*—This species occurs in the Victorian Lower Miocene and is commonly dredged off Victoria and South Australia, numerous specimens being observed in the dredgings taken by Sir Joseph Verco.

##### Hornera robusta Macgillivray, 1883.

*Hornera robusta* Macgillivray, 1883, Trans. Proc. Roy. Soc. Vict., **vol. xix**, p. 291, pl. i, fig. 1; *idem*, 1886, dec. xii, p. 72, pl. cxviii, figs. 6-8.

*Observations*—This species occurs commonly off the Victorian coast, but this is its initial record as a fossil.

### Family TUBULIPORIDAE Johnston, 1838.

#### Genus Idmonea Lamouroux, 1821.

##### Idmonea australis Macgillivray, 1882.

*Idmonea australis* Macgillivray, 1882, dec. vii, p. 30, pl. lxviii, fig. 2. Busk, 1887, p. 12, pl. iii, fig. 3.

*Observations*—This species is recorded fossil for the first time. At the present day, it is found from Port Jackson around the coast to South Australia.

##### **Idmonea macgillivrayi**, sp. nov.

(Text fig. 3.)

*Idmonea milneana* Macgillivray (*non* d'Orbigny, 1839), 1882, dec. vii, p. 29, pl. lxviii, figs. 1, 1 *a, b*.

(Not *Platonea scalaria* Canu and Bassler, 1922, p. 49, pl. xi, figs. 1-5.)

(Not *Diaperoecia scalaria* Canu and Bassler, 1929, p. 537, pl. lxxxi, figs. 3-7.)

*Observations*—Canu and Bassler recognise that Macgillivray's figured

specimen is incorrectly referred to *I. milneana,* but they place his form with their Philippine species, *I. scalaria.* The southern Australian form, however, differs from both Atlantic and Philippine forms in being much more robust and having four or five zooecial tubes to each alternating fascicle, instead of two to four.

*Dimensions*—Width of branch 2·1 mm.; zooecium, length 0·6-0·8, width 0·25-0·30; aperture, diameter 0·18-0·22.

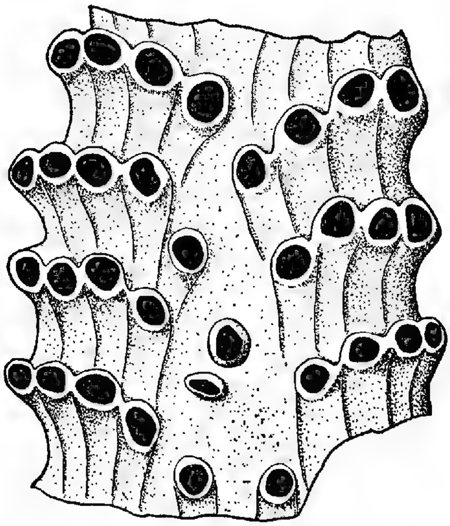

Fig. 3.
*Idmonea macgillivrayi,* sp. nov. Glanville Bore at 415 to 445 feet. Plesiotype, South Aust. Mus. Coll., No. L 11. Portion of branch showing ooeciostome.

## Conclusions.

Apart from the species described as new, all the forms are known to be living at the present day, except *Thalamoporella gracilis* Maplestone, 1902, which has been recorded previously only from the Lower Pliocene (Kalimnan) of Jemmy's Point, Lakes Entrance (Victoria). A recent study of a Lower Pliocene bryozoan faunule from Hamilton (Victoria) (Stach, 1935, *a)* revealed only one species ranging from Miocene to Pliocene, and one new species, *Otionella grandipora,* which has since been found in dredgings from off Beachport (South Australia). The lack of typical Miocene forms and the recent aspect of the faunules fixes the age as later than Miocene, while the occurrence of *Thalamoporella gracilis* suggests that the faunule is Pliocene. The faunule is consistent with an Upper Pliocene age as far as our present knowledge can be applied, since no restricted Miocene form has been found, while in the Lower Pliocene, as noted above, one such species has been recorded.

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## EXPLANATION OF PLATE XV.

### Bryozoa from Cowandilla Bore, S.A.

Fig. 1. *Cellaria variabilis* (Busk, 1884). Cowandilla Bore at 520 to 550 feet. Plesiotype, South Aust. Mus. Coll., No. L 7.

Fig. 2. *Thalamoporella howchini*, sp. nov. Cowandilla Bore at 485 to 507 feet. Holotype, South Aust. Mus. Coll., No. L 2.

Fig. 3. *Cellaria australis* Macgillivray, 1880. Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 6.

Fig. 4. *Sertella porcellana* (Macgillivray, 1869). Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 9.

Fig. 5. *Adeonellopsis australis* Macgillivray, 1886. Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 10.

# ON THE ECOLOGY OF THE BLACK-TIPPED LOCUST (CHORTOICETES TERMINIFERA WALK.) IN SOUTH AUSTRALIA

*BY J. DAVIDSON, D.SC.*.

## Summary

A widespread plague of locusts developed over the agricultural areas of South Australia during 1934 and 1935. The species concerned was *Chortoicetes terminifera* Walk., which has a wide distribution in Australia *(vide* Sjostedt, 1921, p. 41 ; 1935, p. 31). The species also occurred in plague numbers during this period over the northern districts of Victoria, western districts of New South Wales and certain areas in Queensland. It was present in smaller numbers in portions of the south-west districts of Western Australia. An examination of the literature on locusts and grasshoppers in Australia shows that this species has occurred in plague numbers from time to time since the early days of settlement. The seasonal conditions which favoured these outbreaks also favoured the multiplication of certain species of gregarious grasshoppers. Owing to the characteristic black area at the tips of the hindwings in *Ch. terminifera,* it is generally possible to recognise references to this species in the literature, if the winged form is described. Where reference is made to the habits of the wingless hoppers, it is evident that some of the earlier accounts refer to more than one species of gregarious grasshoppers.

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By J. Davidson, D.Sc.
(Waite Agricultural Research Institute, University of Adelaide.)

[Read October 8, 1936.]

## I INTRODUCTION.

A widespread plague of locusts developed over the agricultural areas of South Australia during 1934 and 1935. The species concerned was *Chortoicetes terminifera* Walk., which has a wide distribution in Australia *(vide* Sjostedt, 1921, p. 41; 1935, p. 31). The species also occurred in plague numbers during this period over the northern districts of Victoria, western districts of New South Wales and certain areas in Queensland. It was present in smaller numbers in portions of the south-west districts of Western Australia.

An examination of the literature on locusts and grasshoppers in Australia shows that this species has occurred in plague numbers from time to time since the early days of settlement. The seasonal conditions which favoured these outbreaks also favoured the multiplication of certain species of gregarious grasshoppers. Owing to the characteristic black area at the tips of the hindwings in *Ch. terminifera,* it is generally possible to recognise references to this species in the literature, if the winged form is described. Where reference is made to the habits of the wingless hoppers, it is evident that some of the earlier accounts refer to more than one species of gregarious grasshoppers.

From observations carried out in South Australia during the past two years, it has been established that while *Ch. terminifera* was the chief species concerned in the recent plague in this State, a gregarious species of *Austroicetes* also occurred in large numbers in portions of the infested areas; this species is provisionally considered to be *A. jungi* Brancsik, 1897. The writer visited the Eastern States during the spring of 1934, and again in 1935, and was able to discuss the locust problem with the entomologists in these States. *Ch. terminifera* was widely distributed in plague numbers in certain areas of these States; one or more species of gregarious grasshoppers were also present in parts of the infested areas.

Owing to the lack of precise knowledge about *Ch. terminifera,* it has not been generally accepted as a locust in the literature. Outbreaks in the early days of South Australia were referred to in the press as "Locust plagues." The "locust plague" in Victoria in 1873 was evidently due to *Ch. terminifera (vide* Bath, 1873, p. 69); Olliff, in 1890, calls it the "plague locust" in New South Wales; Tepper, in 1891, calls it the "wandering locust" in South Australia; Koebele, in 1891, refers to it as the "migratory locust"; Froggatt, in 1903, in New South Wales, refers to it as the "larger plains locust"; and in 1909 as the "wandering plague locust"; Uvarov, in 1928, states it should be classed as a gregarious grasshopper and calls it "the wandering grasshopper."

From observations on the habits of the species during the recent plague, the writer considers that *Ch. terminifera* should be classed as a "locust." The words "wandering," "migrating" and "plague" applied to a locust are redundant, and the name "black-tipped locust" is proposed for this species. The regions in which plagues of this species originate in South Australia (reservation areas), are situated in the drier areas of the State, north of the wheat belt. The species temporarily invades the agricultural areas and has a relatively wide range of migration; swarms are known to reach the south coast and pass out to sea. The

term "wandering grasshopper" might be appropriately applied to certain species of *Austroicetes*, such as *A. Jungi* Brancsik.

The preliminary account of *Ch. terminifera* given in this paper is based on observations made in South Australia during the past two years. Work is in progress relating to the biology of the species and the delimitation of its reservation areas.

## II NOMENCLATURE OF CHORTOICETES TERMINIFERA

The species was first described by F. Walker as *Epacromia terminifera* in 1870 (Cat. Derm. Salt. Br. Mus, iv, p. 777). The type collected in Western Australia (Swan River) is in the British Museum. Brancsik, in 1895 (Jahresb. Ver. Trencs. Com. xvii-xviii, p. 249), placed a new species, *yorketownensis*, in the genus *Chortoicetes*; this genus was described by Brunner in 1893 as differing from *Epacromia* (Rev. Syst. Orthopt., p. 123), but Brunner did not name any species with the genus; *Ch. yorketownensis* is a syn. of Walker's *Epacromia terminifera*. Kirby, in 1910 (Cat. Orthop. III), placed *terminifera* as genotype of *Chortoicetes*. Sjostedt, in 1921, p. 40, disagreed with Kirby's placing of *terminifera* and created a new genus for it, namely, *Calataria*, with Walker's *E. terminifera* as genotype.

B. P. Uvarov, in 1924 (Trans. Entom. Soc., London, p. 271), discusses the generic placing of *"terminifera"* and concludes that it is rightly placed as the genotype of *Chortoicetes* (Brunner 1893, Brancsik 1895); *Calataria* Sjostedt, 1921, is placed as an absolute synonym of *Chortoicetes* Brancsik, since the former genus is based on the same genotype. Uvarov proposes the name *Austroicetes* n.n. for *Chortoicetes* Sjostedt, 1921 (nec. Brancsik, 1895), with *Epacromia pusilla* Walk. as its genotype.

Sjostedt, in his second monograph of 1935, p. 31, retains *terminifera* in the genus *Calataria*.

In Australian literature, *Ch. terminifera* has been referred to as *Decticus verrucivorus* (Bath, 1873). In a prefatory note by A. R. Wallis to Bath's paper dealing with observations on the locust plague of 1873 in Victoria, the species is figured (pl. ii, fig. 66) under the name *Oedipoda musica* Fab. This is evidently an error for *Decticus verrucivorus*, since *Gastrimargus musicus* is figured under that name; Froggatt, in 1903, placed *Decticus verrucivorus* of Bath as a synonym of *Ch. terminifera*. Tepper, in 1891, refers to the species as *Epacromia terminalis* Walk. Koebele found it in large numbers in South Australia, 300 miles north of Adelaide, in 1890, and in 1891 refers to the species as *Chortolga australis*. Olliff, in 1890, refers to the species as *Pachytylus australis* Brunner; the figure given shows he was referring to *Ch. terminifera*. It was known under the former name in Australian literature until Froggatt, in 1903, dealt with it as *Ch. terminifera*, which was the name subsequently applied to it. Sjostedt (1921, p. 41; 1935, p. 31) gives a useful synonymy.

## III RECORDS OF THE OCCURRENCE OF CH. TERMINIFERA IN SOUTH AUSTRALIA.

The province of South Australia was founded in 1836. It is recorded that hordes of locusts visited Adelaide in 1844 and devastated gardens (Edwin Hodder, History of South Australia, 1893, vol. ii, p. 165). From the description of the flight of these locusts, it is highly probable that the species was *Ch. terminifera*. "The Register," Adelaide, December 16, 1871, reports "On December 15th an enormous swarm of locusts flew over the city, darkening the sky." This was, doubtless, *Ch. terminifera*. We know from the account given by Bath (1873) that this species occurred in plague numbers in parts of Victoria during 1872; Bath refers to locust swarms in the Wimmera in 1848, 1862 and 1869, but the writer has no evidence to show if the species concerned was *Ch. terminifera*.

Species of *Austroicetes* were, doubtless, also associated with these early outbreaks.

In addition to the above references, there are numerous reports in the early South Australian newspapers relating to "locust" outbreaks in the northern agricultural areas of the State. In the light of our present knowledge, it is clear that many of these reports refer to gregarious grasshoppers, which have a more local range of migration in the wheat belt; presumably they were chiefly due to *Austroicetes* sp. (*? jungi*). After 1871 locusts received less attention in the South Australian press. This cannot be interpreted as indicating that they were not troublesome; with the development of other interests in the State, local outbreaks of locusts had less news value.

A widespread plague of *Ch. terminifera* developed in 1890 (*vide* Tepper, 1891). It extended over the northern districts of Victoria (*vide* Insect Life, vol. iii, p. 419) and western districts of New South Wales (*vide* Olliff, 1890, 1891). There does not appear to be any record of outbreaks of this species in South Australia in subsequent years, until the recent plague. Grasshoppers were recorded in large numbers in 1908 in northern districts, particularly about Orroroo, Wilmington and Quorn. The evidence indicates that restricted outbreaks frequently occurred in those districts. Recent information suggests they were due to *Austroicetes jungi* (*vide* Andrewartha, 1936).

Although widespread locust outbreaks, similar to those of 1890 and 1934 do not appear to have developed in South Australia in the intervening years, swarms occurred, from time to time, over restricted areas in the northern portions of the State (reservation areas).

The following earlier records are taken from collections in the South Australian Museum.[1] Unfortunately, the available information does not show whether the specimens were solitary individuals or collected from swarms.

1886: January—Murray Bridge; March—Adelaide.
1887: March—Adelaide.
1888: Jan.—Murray Bridge; February—Gremtinta, Dowlingville (Y.P.).
1890: February—Adelaide; April—Lyndoch, Tanunda.
1924: Wilpena Pound.

Other records (without date labels) are Parachilna, Karoonda, Owieandana, North Flinders Range, Mount Serle, Ooldea and Kingoonya.

## IV DESCRIPTION AND BIOLOGY OF CH. TERMINIFERA.

### (a) The Adults.

There is considerable variation in the appearance of adults; certain variations occur in association with the "phases" of the species. Adults taken from swarms have a slender appearance, the wings extending about one-third of their length beyond the abdomen. The general colour of both sexes is dark brown, but green forms occur in swarms, or as solitary individuals. The characteristic feature is the sharply defined, dark brown to black pigmented area at the tip of the hind wings; otherwise the hind wings are clear. The fore wings bear a number of dark patches distributed over their length. These features are shown in the photographs given in a previous paper (Davidson, 1934). The pronotum has a faint median carina without a lateral keel, and exhibits well-defined constrictions; with many specimens it bears an inverted "V"-shaped marking, and a median, pale band may extend forward over the head; these characters vary and may be obscured in darker individuals. The femur of each hind leg bears two dark bands; they extend over the outer and dorsal faces of the femur; in association with the dark patches on the basal portion of the fore wings, they give the insect a somewhat "banded" appearance. The inner faces of the hind femora are red,

(1) I am indebted to Dr. K. H. L. Key for identification of the specimens.

becoming pale at the distal end; the knees are black; the tibiae are pale over the proximal end, being red over the remainder of their length.

*(b) The Nymphs.*

The nymphs (hoppers) exhibit certain general features in all five instars; there is, however, a wide range of variation in colour pattern. As with the adults, certain variations are associated with the "phases" of the species. In general, the nymphs are dark to black with an underlying dirty-grey or brownish colour. In all instars there is a whitish X-shaped marking on the head and pronotum; and a dorsal, median, whitish or buff-coloured stripe extends along the length of the body. The femur, in the hind legs, bears two dark fasciae; the tibiae are black at the proximal end and over the distal two-thirds, with an intervening pale band; each tibiae bears an outer row of ten spines, an inner row of eleven spines, and four larger, articulated spines at the distal end. The sex of the nymphs can be diagnosed in all instars from the character of the terminal abdominal structures, which resemble those figured by Uvarov (1928, p. 48) for *Locusta migratoria.*

The *1st instar nymph* is pale in colour on emerging from the pronymphal moult; at 30° C., the characteristic dark colour develops within 1½ hours. Wing rudiments are not visible, but they may show up in spirit material. In the *2nd instar,* wing rudiments are visible, but the appearance of the incipient venation is not evident until the *3rd instar.* In the *4th instar,* a whitish area is seen about the base of the hind wing; this feature is maintained in the *5th instar;* in the latter stage the tibiae of the hind legs may exhibit a reddish tinge.

*(c) The Eggs.*

The eggs are yellowish-brown in colour. The chorion may exhibit an irregular hexagonal pattern of ridges which represents the lines of contact with the frothy secretion produced by the female during oviposition. The micropyle area is posterior, being defined by a sub-terminal row of pores.

*(d) The Egg Pods.*

The eggs are laid in typical "pods." They are disposed vertically in four parallel rows, each egg lying obliquely to the long axis of the pod. The eggs are embedded in a glistening, whitish, frothy secretion which also composes the walls of the pod. The upper third of the pod does not contain eggs; it is filled with the frothy secretion referred to above. The pods are usually disposed vertically in the soil to a depth of 2½ to 3 inches, but occasionally they are disposed obliquely.

The number of eggs in a pod varies. With 51 pods which were removed from the soil and the eggs counted, 6 pods had 20-30 eggs, 23 had 30-40 eggs, 19 had 40-50 eggs, and 3 had 50-60 eggs. These numbers compare with those recorded by previous observers: Bath (1873), 32 to 45 eggs per pod; Gurney (1919), 36; Johnston and Gross (1935), 30-50.

*(e) Oviposition.*

Field observations during the recent plague show that the females crowd in dense numbers for egg-laying on selected sites. In the wheat belt zones these are generally hard, bare areas, stock roads, thin pastures, dry hard flats, hills with gravelly soil carrying short, native grasses, and banks of creeks. The egg beds may cover a few square yards or many acres, according to the size of the swarms. In the more intensive agricultural zone, during the peak of the plague, the insects laid in various soils, in crops, in fallow soil, and in irrigated swamp soils bordering the River Murray. Up to 200 pods per square foot were recorded in egg beds at Renmark.

Observations during the past two years show that *Ch. terminifera* occurs in the solitary phase over a wide area of the State (see Andrewartha, 1936, 1936a). This wide distribution may be the outcome of the recent plague, but the insect will probably be found permanently in various localities over the wheat belt and

the pastoral zone. Eggs must be laid by these solitary individuals over a wide area, but it is interesting to note that there was no evidence in connection with the early stages of the recent plague, that swarms were initiated in the wheat belt zone. The writer made an extensive tour in the pastoral country in October, 1936; solitary individuals of *Ch. terminifera* were taken over a wide area, extending to Coward Springs in the north and west of Ceduna in the west.

*(f) Development of the Eggs.*

The eggs do not develop in dry soil. Where moisture and temperature are suitable, development appears to take place, without any enforced diapause. Successive generations of the species have been reared in the heated insectary. Change to low temperatures or dryness inhibits development. Experimental data are not yet available for the influence of temperature and moisture on development; eggs laid in dry soil, when remoistened at 30° C., hatched in 13 days.

When the embryo is mature, the chorion is ruptured with the aid of the cervical ampulla, and the "vermiform larva" (Uvarov, 1928) works its way to the soil surface, where it casts it pronymphal moult.

*(g) Habits of the Nymphs.*

The nymphs remain for a day or two hopping about the egg beds. Later they become more definitely gregarious and advance in dense bands along an irregular front, through sparse vegetation; they do not like dense, green herbage. Activity depends largely on temperature. On cool, dull days they remain sluggish and gather together in irregular, dense clusters in the shelter of depressions in the soil, or behind suitable protective vegetation (*vide* Davidson, 1934). When disturbed, they become agitated and hop about vigorously for a time, but soon reform. In the early morning, they are sluggish; they may be seen sitting on stones or pieces of dry sticks, with the long axis of the body directed to the sun. During hot days (temperatures over 90 ° F.) the hoppers are very active (see observations by Johnston and Gross, 1935). The writer has seen nymphs hopping in a continuous procession down the dry creeks leading from hills carrying extensive areas of egg beds. The insects were not interested in feeding; they advanced continuously during the warm hours of the day. The density of the hopper swarms is amazing; the ground may be completely covered with the insects.

In the wheat belt areas the hoppers feed preferably on native grasses, such as *Danthonia* and *Stipa*, or introduced grasses, such as "barley grass *(Hordeum murinum)*; they readily attack cereal crops, feeding chiefly on the flag, although the ear is also attacked. The insects eat through the stems and leaves, and the hoppers on the ground feed vigorously on the fallen plants. They also eat through the stems of grasses near ground level. Apart from these plants, the hoppers will feed on almost any green plants composing the sparse vegetation.

In the more southerly agricultural areas the insects feed on pasture grasses, lucerne, lawns and many other crops. In general, however, it would seem that the nymphs find the environment of the sparse vegetation of the drier districts more suitable. Hoppers were observed feeding on larkspur *(Delphinium)* in gardens in the northern wheat districts. They eat the leaves, which contain poisonous alkaloids, and die round the plants. This has long been known, as is seen by the numerous references in the local press during previous plagues. Suggestions have been made that the plant might be cultivated as a trap.

Complete development of the nymphs takes about 4-6 weeks under field conditions in summer in South Australia.[2]

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[2] Eggs collected in the field in February, 1935, hatched in cages in the open-air insectary on February 25; some nymphs became adult by April 7 (41 days); mean temperature for the period was about 70° F.

Eggs were laid in soil in cages in open-air insectary in December, 1935; soil was allowed to dry out and then remoistened later. Eggs hatched June 5, 1936, and nymphs reared in a heated cabinet. Some nymphs became adult by July 9. Oviposition first noted August 4.

*(h) Habits of the Adults.*

For one or two days after the final moult, the winged adults make short, irregular, hop-like flights. Later, they make longer flights in swarms. The swarms vary considerably in size; a number of discontinuous swarms may be distributed over a large area of country. These swarms often seem to make short, indefinite flights, the direction of which varies. When the swarms extend more continuously over the country, flight may be continued for days in one direction, so that marked migratory progress is made. From the areas bordering on the northern part of the wheat belt, these flights are often in a southerly direction; this is also the case in the southern part of the pastoral zone. Hot north winds may assist in this, since southerly winds are cool and the insects would be less active. Although the insects become sluggish with a "cool change," and during the nights, there is evidence that they fly during hot nights. In general, the insects appear to fly at heights varying from 50 to 200 feet; it is possible, however, that they migrate at much higher levels. Bath (1873) records swarms advancing south at Learmouth (Victoria) in January at 6-8 miles per hour, the density being one individual per square inch. Bath observed them flying at a height of about 300 feet across a lake one mile wide. Professor Harvey Johnston took two individuals on the Polar Research ship, "Discovery," at sea, 80 miles south of Kangaroo Island. Mr. N. B. Tindale informed me that the lighthouse-keeper at Cape Borda (K.I.) reported a swarm flying against the light on November 10, 1935; this swarm, doubtless, came from Eyre Peninsula, 60 miles away.

The available food plants are restricted in the arid north, and any green herbage may be eaten. In the agricultural zone the insects feed on pasture grasses, lucerne, lawns, vines, fruit trees and garden crops.

## V THE PHYSICAL ENVIRONMENT OF CH. TERMINIFERA IN SOUTH AUSTRALIA.

In order to understand the ecology of *Ch. terminifera* in South Australia, it is necessary to consider briefly the physical environment of the insect as determined by the topography, climate and vegetation of the State.

*A. Topography.*

The general distribution of the highlands is shown in fig. 1. The central ranges, consisting of the Mount Lofty Range in the south, continue northwards as the Flinders Range. The former attains an altitude of 2,334 feet near Adelaide (Mount Lofty), and the latter 3,174 feet near the head of Spencer Gulf (Mount Remarkable). The relief effect of these ranges on rainfall is illustrated by the northward trend of the 10-inch annual isohyet (fig. 2). In the north-west corner of the State, the Musgrave Ranges attain an altitude of some 5,000 feet.

Extending westwards from Lake Gairdner, the country merges into the arid region of Miocene limestone known as the Nullarbor Plain. Westwards and northwards from Lake Eyre much of the area consists of desert sandstone and gibber plains, once the bed of a cretaceous sea. The arid country extends southwards, west of Lake Torrens, towards the head of Spencer Gulf. Eastwards from Lake Eyre, sandhills with claypans and gibber plains are the chief features of the country. Much of this area receives an average annual rainfall only of about 5 inches (fig. 2). However, the rainfall fluctuates widely about this mean; in certain seasons, after heavy rains, the numerous creeks which lead into Lake Eyre basin and Lake Frome may flood over a wide area.

East of the Flinders Range the country consists of an arid plain, which extends southwards across the River Murray into the better rainfall districts comprising the South-eastern area of the State.

The general soil type over the northern portion of the State is classed as Desert Steppe soils; the mallee occupies the greater part of the southern portion, with red brown earths in the higher rainfall districts of the Mount Lofty Ranges, and in the south-east corner of the State (Prescott, 1931).

*B. Rainfall.*

The chief feature of the rainfall in the southern portion of the State is the well-marked incidence of winter rainfall, the summer months being dry (see data

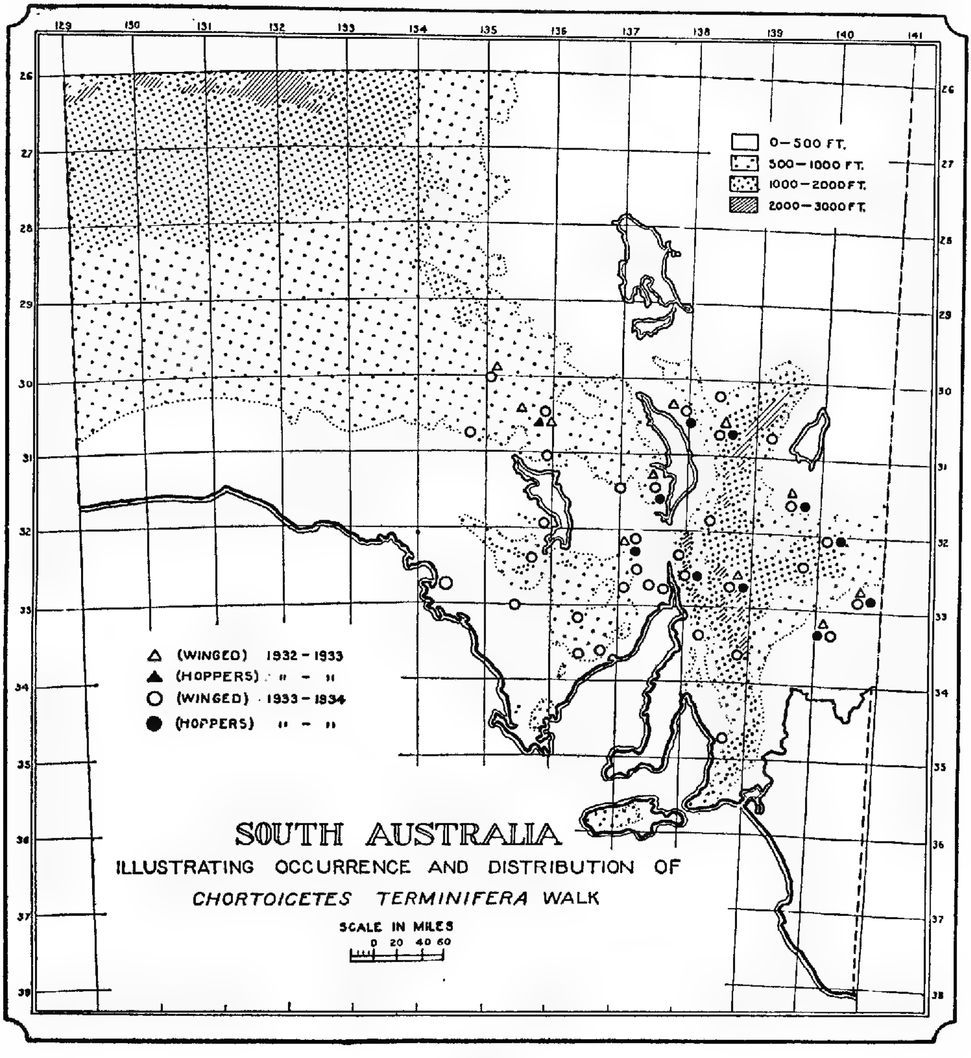


Fig. 1.

Showing distribution of the highlands in South Australia, and districts in which swarms of the black-tipped locust were recorded during 1932-34.

for Roseworthy, Table I). The average annual precipitation is greatest in the south-east (Mount Gambier, 30·64 inches), and in certain elevated districts in the Mount Lofty Ranges (Stirling West, 46·78 inches); it progressively decreases towards the north (see data for Farina, Table I). The reliability of the average amount of rain being received in any year also decreases markedly towards the

north; there are wide fluctuations about the mean resulting in drought years interspersed with seasons in which rainfall is well above the average. In the portion of the State situated north of the 10-inch annual isohyet (fig. 2), mean annual rainfall figures, and even mean monthly rainfall data, are of little value for detailed ecological studies; individual falls of rain have to be considered.

In the far north the influence of the northern monsoon causes irregular heavy rains in the summer months. This region is outside the influence of the winter rainfall system, which is illustrated by the data for Charlotte Waters (Table I), situated just north of the South Australian border in Lat. 25° 56′, Long. 134° 55′. The observations of Osborne and his colleagues at Koonamore illustrate particular features of the rainfall in the arid northern portions of the State. From an agricultural point of view, South Australia may be conveniently divided into three zones, the agricultural development of which is determined by rainfall. Intensive agriculture is practised in the south, in regions having an average annual rainfall about 18 inches or over. The pastoral zone extends northwards from about the 10-inch annual isohyet; it occupies 82% of the total area of the State (see fig. 2). The wheat belt is situated in the intermediate zone, but the limits for safe wheat cultivation do not extend so far north as the 10-inch annual rainfall line (see fig. 4).

TABLE I.

*Showing average monthly rainfall for selected stations; the figures show points of rain, 100 points = 1 inch.*

| Station | Yearly Records | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Roseworthy .... | 44 | 70 | 59 | 80 | 138 | 185 | 245 | 193 | 211 | 195 | 166 | 104 | 86 | 1732 |
| Farina .... .... | 52 | 51 | 55 | 66 | 41 | 64 | 88 | 37 | 41 | 47 | 48 | 49 | 61 | 648 |
| William Creek .. | 57 | 51 | 42 | 60 | 41 | 41 | 64 | 23 | 28 | 40 | 41 | 48 | 56 | 535 |
| Charlotte Waters | 57 | 78 | 63 | 62 | 46 | 36 | 42 | 21 | 19 | 18 | 32 | 48 | 63 | 528 |

*C. Soil Moisture.*

The importance of rain from the viewpoint of ecology is primarily due to its effectiveness in maintaining adequate moisture in the soil for the growth of plants; soil moisture is important in relation to the development of the eggs of the locust. The writer has discussed in earlier papers the value of the ratio of monthly Precipitation to Evaporation (P/E) as an index to the effectiveness of rain in this respect. It has been shown for South Australia, that during the months in which this ratio is 0·5 or over, based on Adelaide records, there will be sufficient moisture available for plant growth in the soil, and these months may be considered as the "growing period"; the remaining months in which the value of this ratio lies below 0·5 are to be considered as dry months and constitute the dormant season (see Davidson, 1935a, 1936).

It is seen from fig. 2 that, in the arid north of the State, the ratio P/E, based on mean monthly data, does not attain the value 0·5 for any one month of the year. Owing to the wide fluctuation of rainfall in this zone, the records for individual years have to be considered; in certain seasons, the rainfall in particular months may bring the ratio well above the value of 0·5; creeks may flow and large areas may be flooded, resulting in luxuriant growth of ephemeral vegetation.

*D. Temperature.*

Over the greater part of South Australia, the average air temperature for the coldest month does not fall below 50° F.; in certain elevated districts in the Mount Lofty Ranges the average for this month may fall to 45° F. The range of temperature over the State is illustrated in Table II.

TABLE II.

*Showing average monthly temperature for selected stations.*

| Station | Yearly Records | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mount Gambier .... | 65 | Max. | 76 | 78 | 74 | 68 | 62 | 58 | 57 | 59 | 62 | 66 | 70 | 73 | 67 |
| | | Min. | 53 | 54 | 52 | 49 | 46 | 44 | 42 | 43 | 44 | 46 | 49 | 51 | 48 |
| Roseworthy .... | 22 | Max. | 87 | 88 | 82 | 74 | 66 | 61 | 60 | 62 | 67 | 73 | 79 | 84 | 74 |
| | | Min. | 58 | 59 | 55 | 51 | 48 | 44 | 42 | 43 | 45 | 48 | 53 | 56 | 50 |
| William Creek .... | 39 | Max. | 96 | 96 | 90 | 80 | 71 | 65 | 64 | 69 | 76 | 84 | 91 | 95 | 82 |
| | | Min. | 69 | 70 | 64 | 55 | 47 | 43 | 41 | 44 | 49 | 56 | 63 | 67 | 56 |

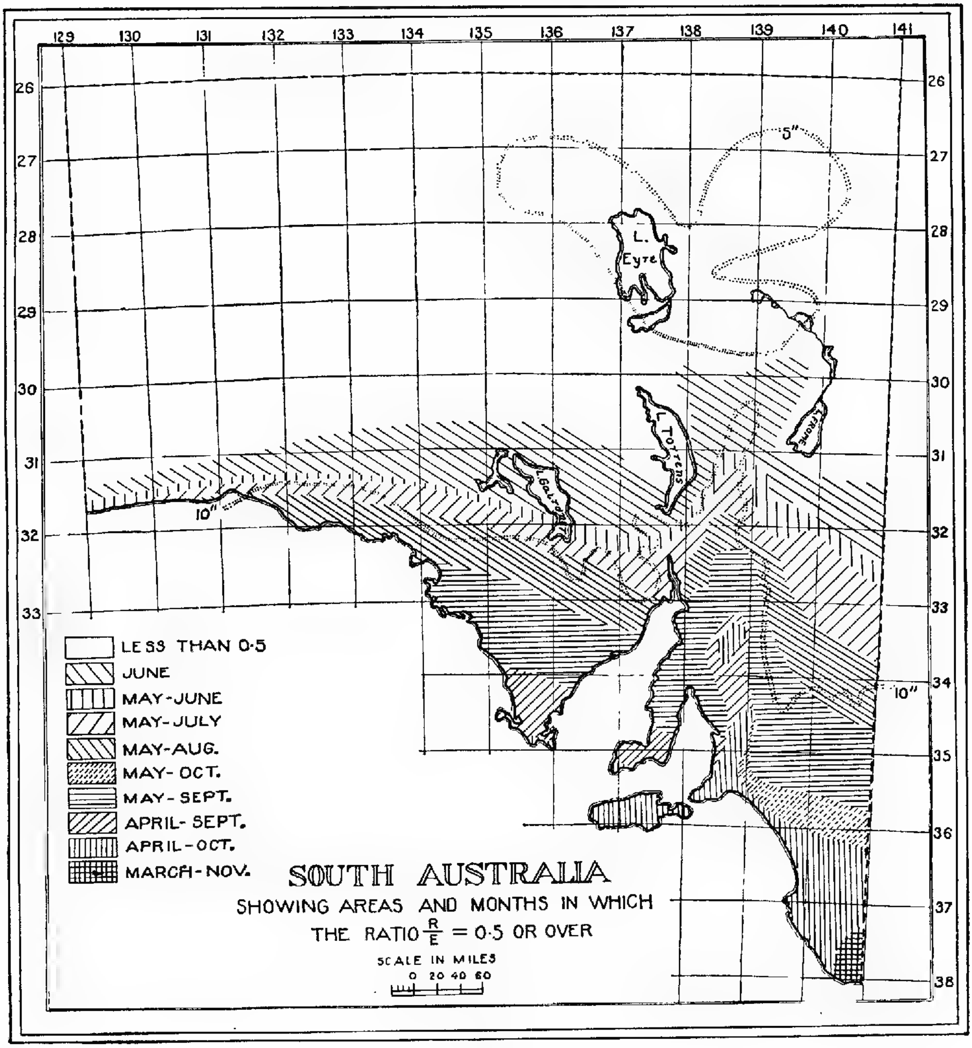


Fig. 2.

Showing areas and months for South Australia in which soil moisture is adequate for the development of locust eggs and the growth of annual plants (R/E — 0·5 or over); they are based on average monthly records for precipitation and atmospheric saturation deficit, which may vary considerably from year to year. The 10-inch and 5-inch annual isohyets are also shown.

In the semi-arid and arid pastoral zones, the daily range of temperature is high. Frosts may occur during the period May to September; temperatures may be below freezing at night and uncomfortably warm during the day. These features are important in relation to the true value to be allotted to the mean (*vide* Osborne et al., 1935; Davidson, 1935).

*Soil Temperature.*—Data for soil temperatures are not readily available; they are important in relation to the actual temperature experienced by the locusts at the soil surface, and by the eggs in the soil. Owing to the variable character of the soil surface and its vegetative covering, it is necessary to obtain temperature data for local situations. The average monthly shade temperatures, and soil temperatures at 1 inch depth on fallow soil, taken from the Waite Institute records, are given in Table III.

TABLE III.

*Showing average monthly soil temperature at 1 inch depth, and air temperature, at the Waite Institute, during the 10 years, 1925-35.*

| Temperature | | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air .... | Max. | 81 | 82 | 79 | 71 | 64 | 59 | 57 | 59 | 64 | 68 | 74 | 79 | 70 |
| | Min. | 60 | 61 | 60 | 54 | 50 | 47 | 45 | 45 | 48 | 50 | 55 | 57 | 53 |
| Soil .... | Max. | 113 | 109 | 102 | 85 | 73 | 65 | 63 | 66 | 74 | 85 | 99 | 109 | 87 |
| | Min. | 66 | 65 | 63 | 56 | 51 | 48 | 47 | 48 | 51 | 55 | 61 | 64 | 56 |

## E. *Humidity.*

The monthly trend of humidity, expressed as atmospheric saturation deficit, is shown in a previous paper (Davidson, 1934a). Observations by Osborne, Wood and Paltridge (1935) at Koonamore show that the average minimum humidity in the semi-arid north may fall below 35% at any time from September to March, inclusive; the mean maximum humidity may exceed 80% in every month. These observations illustrate the wide daily range in humidity. Dry north winds and a high degree of insolation intensify the arid conditions. The range of humidity over the State is illustrated in Table IV.

TABLE IV.

*Showing average monthly humidity for selected stations.*

| Station | Yearly Records | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mt. Gambier | 65 | 58 | 60 | 65 | 75 | 82 | 86 | 85 | 81 | 74 | 68 | 65 | 61 | 72 |
| Roseworthy | 22 | 45 | 48 | 53 | 64 | 75 | 84 | 85 | 78 | 71 | 59 | 50 | 48 | 63 |
| William Creek | 39 | 32 | 33 | 36 | 43 | 51 | 60 | 55 | 48 | 38 | 31 | 30 | 30 | 41 |

## F. *Vegetation.*

The zones of indigenous vegetation afford a valuable guide to the climate and soil of the State. The distribution of the dominant vegetation types is shown in fig. 3, which is based on the coloured map prepared by Trumble (1935) on information established by J. G. Wood and J. A. Prescott. The vegetation zones A-F occupy the major part of the pastoral country and comprise climax associations of various desert or semi-desert types.

*Zone A*—The country consists mainly of desert sandstone and sandhills carrying porcupine grass or spinifex *(Triodia irritans* and *T. pungens)*, with an area in the north-west (D) interspersed with mallee.

*Zone B*—Here we have the extensive zone of the mulga *(Acacia aneura* and related species), with which are associated semi-desert shrubs, also cotton bush *(Kochia aphylla)* and bluebush *(K. sedifolia)*.

*Zone C*—This consists of an extension of the desert sandhills of Zone A interspersed with the vegetation types found in Zone B.

*Zone D*—A restricted area of mallee (Zone I) situated in Zone A.

*Zone E*—Here we have a distribution of the mallee type of Eucalypts *(E. dumosa, E. oleosa* and allied species (extending northwards into the semi-desert *Acacia* scrub association (Zone B).

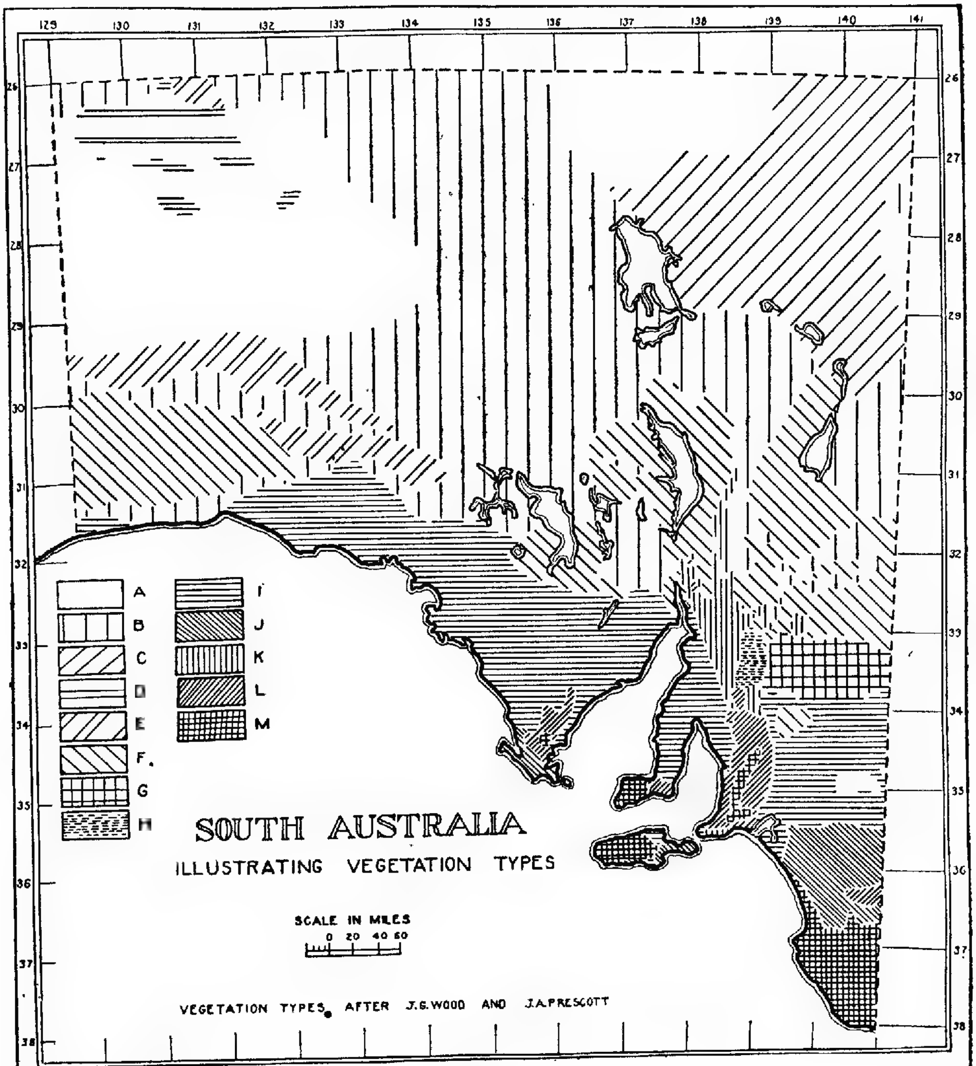


Fig. 3.

Showing the distribution of the main vegetation types in South Australia, which are briefly described in the text.

*Zone F*—This zone, together with G, forms the major area of the saltbush steppe *(Atriplex,* spp.), with which cotton bush and bluebush are associated, particularly in the northern parts of the area.

*Zone G*—Part of the saltbush steppe into which there is a northern extension of the mallee (Zone I).

*Zone H*—An area of iron grass *(Lomandra)* hills with flats.

*Zone I*—This is the extensive zone of the mallee which extends right across the State, south of the saltbush steppe. It is replaced in the central highlands by dry savannah woodland associations (Zone K) and savannah woodland (Zone L).
*Zone J*—Areas of sclerophyll scrub and heath.
*Zone K*—Dry savannah woodland associations.
*Zone L*—Savannah woodland associations.
*Zone M*—Sclerophyll forest associations in the heavier rainfall country.

For further information about the vegetation of these various zones, the reader should consult the papers by Osborn, Wood and Paltridge (1935), and Ratcliffe (1936); these papers contain references to earlier work. Extensive areas of the mallee have been cleared for wheat-growing; portions of the southern areas of the pastoral country have changed considerably owing to stocking and other causes (Radcliffe, 1936).

## VI THE 1934-1935 LOCUST PLAGUE IN SOUTH AUSTRALIA.

The peak of the locust plague in South Australia occurred during the summer of 1934-1935, but evidence has been obtained relating to the development of the swarms in the two previous years. Winged swarms of *Ch. terminifera* developed in local areas in the pastoral zone during the summer of 1932-1933. In one locality a swarm of wingless hoppers was recorded. The few records which have been established by means of survey tours, and reports from holders of pastoral leases, are to be considered as representing the beginnings of the subsequent plague. Doubtless, there were other local swarms scattered over the pastoral country during this period, but owing to the character of the country and the sparse population, it is not surprising that more records are not available. In particular, the chances of scattered gregarious bands of wingless hoppers being observed are very small. It may be noted that individual sheep stations may occupy some 1,000 to 2,000 square miles of country, carrying 20 to 30 sheep to the mile; the greater part of the State above lat. 30° is practically unoccupied.

The winged swarms referred to above were observed during February to May, 1933. They were adults from hatchings induced by local summer rains in particular areas. It is convenient to refer to them as representing the first generation.[3] This generation laid eggs from which nymphs of the second generation commenced to hatch out the following spring (1933). Winged swarms of the second generation were widespread during the late spring and early summer of 1933; they advanced southwards throughout the summer (fig. 1). From the western part of the State, in the region west of Lake Gairdner, they invaded the hilly country (Gawler Ranges) to the south and south-west of this lake. In the central portion of the State, they advanced from the north-east, into the country bordering on the wheat belt (figs. 1 and 4). Eggs were laid in these areas from November onwards. Nymphs of the third generation were hatching in these areas during the summer. This resulted in the development of numerous winged swarms of the third generation in the summer and autumn of 1934. The areas concerned extended across the State at irregular intervals. The swarms advanced southwards into the wheat belt in vast numbers. Eggs were laid in certain areas

[3] The available evidence indicates that small, scattered swarms of *Ch. terminifera* may develop any year in the arid and semi-arid northern country, due to irregular, local falls of rain. When moisture is adequate, hatching may occur in any month of the year, although temperatures during June, July and August are not very favourable. Because of variation in the time of hatching in different areas, it is more suitable to refer hatchings to seasonal periods rather than individual months. In this paper, spring, summer, autumn and winter are considered as including the months September-November, December-February, March-May and June August, respectively.

in the wheat belt and in cleared portions of this belt bordering on the pastoral country.

Owing to the dry autumn of 1934 in the wheat belt area, and the retarding effect of temperature during the winter months, the eggs did not commence to hatch until the early spring of 1934. Nymphs of the fourth generation were hatching out from late August onwards; the time of hatching depended upon the temperature in particular areas. In Eyre Peninsula, in districts about Kimba and Cowell, the nymphs were hatching during September and October, over extensive areas. In certain districts the egg beds extended almost continuously for two or three miles. During the summer of 1934-35, winged swarms of the

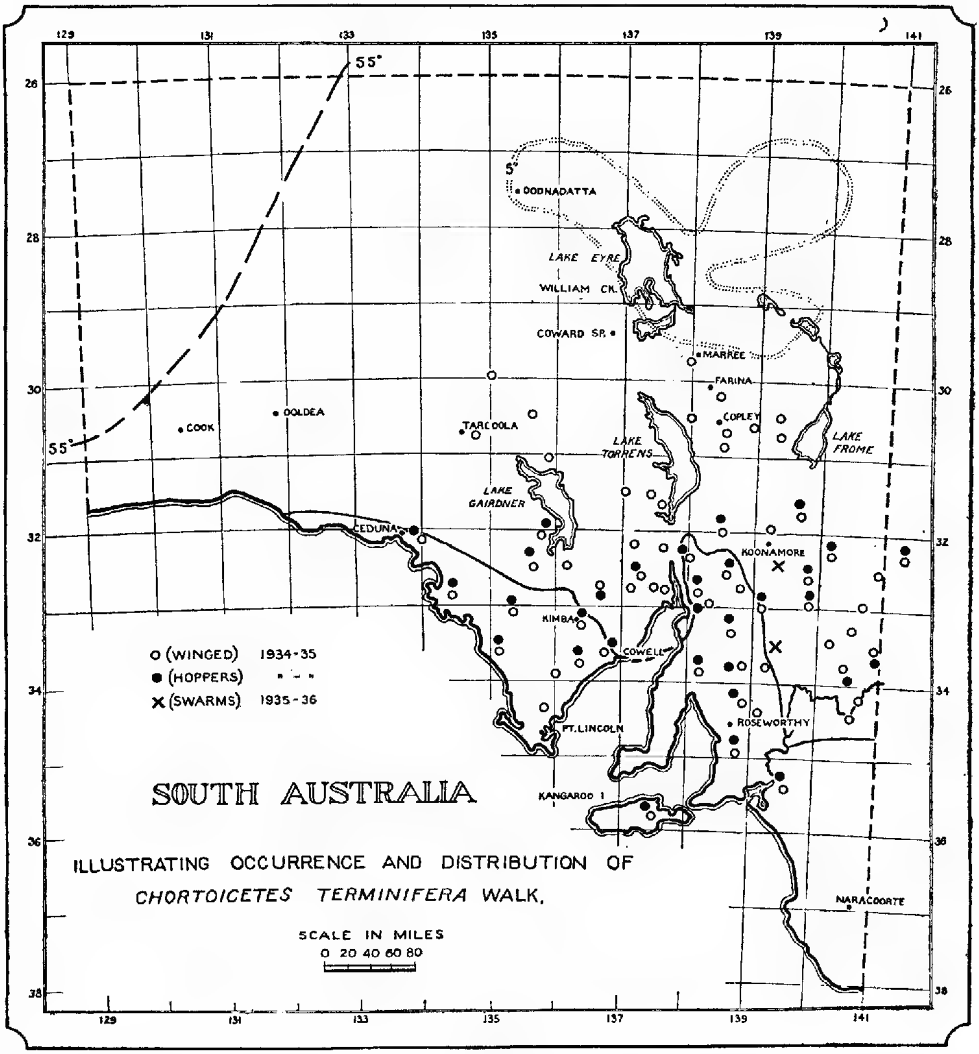


Fig. 4.

Showing representative districts in South Australia in which swarms of the black-tipped locust were recorded during 1934-36. Information relating to their occurrence in the extreme north and west of the State is not available. The course of the 55° F. isotherm for the coldest month (July) is shown. The solid black line marks the northern safe limits for wheat growing. Cleared, undeveloped areas about this line afford important temporary breeding grounds for the black-tipped locust in certain years.

fourth generation extended over a large part of the agricultural areas of the State (fig. 4). They did not extend into the higher rainfall districts of the Mount Lofty Ranges, nor into the south-eastern corner of the State. The extent of the invasion is illustrated in fig. 4, where representative localities in the invasion area are indicated.

Eggs were laid freely in these invasion areas during the summer of 1934-35. Extensive hatching of nymphs of the fifth generation occurred during the early part of 1935 in localities where local summer rains produced adequate soil moisture. In other districts, nymphs were found hatching after the early autumn rains. The nymphs in all these instances died out at an early stage of development. During the summer of 1935-36, only scattered, solitary, winged individuals were found in the invasion areas, with the exception of two small swarms located in November, 1935 (fig. 4); it is highly probable, of course, that small swarms occurred in other localities. The species was found to be widely distributed as solitary individuals over wide areas of the State during the summer of 1935-36. They may represent the aftermath of the plague.

## VII FACTORS AFFECTING THE DEVELOPMENT OF THE PLAGUE.

The breeding grounds of *Ch. terminifera*, in the pastoral zone, occur as restricted localities, scattered across the State. This is due to variation in soil type, vegetation and the irregular distribution of effective rains. The localities in which swarms may develop, and the extent of the swarms, will depend primarily upon the situations in which viable eggs are present, and the distribution of effective rains. Information is not available regarding the occurrence of swarms in the far northern regions of the State. They doubtless occur in restricted, favourable situations, but the arid conditions may not permit of the development of swarms over extensive areas.

The development of the recent plague in South Australia is associated with the occurrence of rains, markedly above the mean, in parts of pastoral zone during the warmer months of 1932 to 1934. These areas are situated in the north-west and north-east pastoral country. The distribution of rainfall during these months in these areas is illustrated in Table V.

In that part of the State which lies south of the 10-inch annual rainfall line, rainfall is more reliable, but the region is under the influence of the winter rainfall system (fig. 2). Locusts hatching out in the autumn, in this region, would normally experience the cold, wet winter months, and the mortality would be heavy; those hatching in spring would be faced with a period of summer drought.

The dry autumn of 1934 in the wheat belt zone favoured the insects, since they hatched out nearer the spring period (Davidson, 1935a). The widespread occurrence of swarms throughout the wheat belt, and the country south of it, during the summer of 1934-35, was chiefly due to the eggs laid by winged swarms which invaded these areas from the north during the previous autumn. The climate in these southern portions of the State is such that this high density of the locust population cannot be maintained for more than one or two seasons. Owing to the varied conditions which must be fulfilled before a widespread plague can develop in these areas, such outbreaks will occur infrequently and at irregular intervals.

The reasons for the widespread deaths amongst the nymphs (fifth generation) which hatched out during the early part of 1935 are not clear. To some extent extreme dryness and lack of green food may have been responsible for this. Development of the eggs and emergence of the nymphs are arrested if the soil dries out, so that the emergence of nymphs in the field may extend over a prolonged period, due to fluctuations in soil moisture. Extreme dryness is harmful at certain stages of development, and the nymphs which eventually emerge may be weakened. In general, the nymphs lacked vigour compared with those of the previous generation.

TABLE V.

*Showing the rainfall in particular months during 1932-34 at certain stations in the pastoral country. Rainfall figures in points (100 points = 1 inch). The mean rainfall is shown in italics.*

| | | Yr. | Jan. | Feb. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| Yardea | North-Western Pastoral Country | Av. | *39* | *59* | *125* | *106* | *94* | *63* | *44* |
| | | 32 | 12 | 178 | 206 | 97 | 73 | 2 | 55 |
| | | 3 | 20 | 0 | 133 | 86 | 25 | 424 | 34 |
| | | 4 | 6 | 109 | 201 | 36 | 111 | 179 | 0 |
| Cook | | Av. | *20* | *57* | *64* | *33* | *32* | *40* | *64* |
| | | 32 | 24 | 138 | 247 | 77 | 100 | 32 | 142 |
| | | 3 | 57 | 0 | 59 | 7 | 25 | 146 | 3 |
| | | 4 | 1 | 2 | 44 | 21 | 37 | 157 | 0 |
| Kingoonya | | Av. | *31* | *62* | *53* | *43* | *66* | *45* | *50* |
| | | 32 | 0 | 211 | 65 | 107 | 162 | 56 | 0 |
| | | 3 | 0 | 0 | 55 | 21 | 13 | 121 | 37 |
| | | 4 | 0 | 73 | 51 | 9 | 43 | 108 | 0 |
| Yunta | North-Eastern Pastoral Country | Av. | *58* | *62* | *72* | *72* | *68* | *79* | *73* |
| | | 32 | 0 | 167 | 102 | 132 | 5 | 21 | 5 |
| | | 3 | 63 | 0 | 69 | 103 | 33 | 331 | 77 |
| | | 4 | 0 | 90 | 18 | 12 | 72 | 139 | 4 |
| Cockburn | | Av. | *57* | *60* | *63* | *60* | *62* | *76* | *64* |
| | | 32 | 0 | 77 | 61 | 74 | 11 | 231 | 70 |
| | | 3 | 17 | 43 | 30 | 52 | 6 | 409 | 2 |
| | | 4 | 6 | 33 | 36 | 97 | 127 | 0 | 564 |
| Waukaringa | | Av. | *46* | *52* | *72* | *65* | *64* | *69* | *67* |
| | | 32 | 0 | 101 | 93 | 122 | 18 | 19 | 0 |
| | | 3 | 8 | 0 | 76 | 24 | 22 | 293 | 25 |
| | | 4 | 22 | 100 | 34 | 19 | 96 | 167 | 0 |

The egg parasite, *Scelio fulgidus* Crawford, occurred widely in the egg beds during 1934-35 (*vide* Noble, 1935). Material was received from Renmark, Burra and Murray Bridge. It appeared freely in egg beds at Murray Bridge, in districts where *Ch. terminifera* had not been recorded for many years. This suggests that it may be a parasite of the eggs of local species of Acridids. Emergence of the parasite from parasitised egg pods is arrested if the soil dries out, so that emergence may extend over a long period under field conditions. A section of soil taken from egg bed at Murray Bridge in February, 1935, was allowed to dry out in the laboratory for 37 days. The average temperature in the room for the period was 72° F. Parasites were emerging from the egg pods when the sample was taken; they ceased to emerge after a few days. The soil was watered on the thirty-eighth day and parasites emerged the same day.

Parasitism of the eggs and the unfavourable physical environment doubtless contributed to the reduction of the locust population.

## SUMMARY.

The Australian "black-tipped locust" (*Chortoicetes terminifera,* Walk.) occurred in plague numbers over a large part of southern and eastern Australia

during 1933-1935. An account is given of the progress of the plague in South Australia, and of certain factors affecting its development. The synonymy of the species is discussed. The general characters of the egg pod, nymphs and adults are described, and an account is given of the chief features of the biology of the nymphs and adults. The physiography, climate and vegetation of South Australia are briefly discussed, since they determine the character of the physical environment of the insect.

## Acknowledgments.

The writer is indebted to Professor A. J. Perkins and several members of the staff of the Department of Agriculture of South Australia; also to Mr. N. McGilp, of the Pastoral Board, for their helpful co-operation in many ways, particularly relating to field observations.

The Council for Scientific and Industrial Research has provided a motor conveyance, so that more extended field work may be carried out on the locust and grasshopper problem in South Australia; the State Department of Agriculture has arranged for a special grant for travelling expenses in this connection. A detailed study is being made of the biology of the species concerned, and of the endemic areas in the State, in which locust and grasshopper outbreaks originate. This work could not have been undertaken without this sympathetic co-operation and generous assistance.

Mr. D. C. Swan and Mr. H. G. Andrewartha, Assistant Entomologists, made observations on *Ch. terminifera* in the field, and on colonies reared in the insectary, which have been incorporated in the paper.

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# DESCRIPTIONS OF THREE NEW SPECIES AND ONE VARIETY OF EUCALYPTUS OF THE ELDER AND HORN EXPEDITIONS, THE "WHITE- WASH GUM" OF CENTRAL AUSTRALIA, AND THE RE-DISCOVERY OF EUCALYPTUS ORBIFOLIA F. V. M.

*BY W. F. BLAKELY*

**Summary**

Arbor 30-45 pedes (ca. 9-13 m.) alta, ramulis, foliis, fructibus maxime glaucis. Folia juvenilia opposita, subamplexicaulia, sessilia vel breviter petiolata, ovata vel oblonga, crassa, glauca, 2-5 cm. longa, 2-4 cm. lata; folia matura petiolata, alterna necnon opposita, oblongo-lanceolata vel falcato-lanceolata, 4-6 cm. longa, 1-2 cm. lata; venae obscurae, venae laterales irregulares, angulo 30-35 graduum a costa media divergentes, vena intramarginalis a crasso margine remota; umbellae axillares, sub-deflexae, 3-9-florae vel floribus pluribus passim praeditae; pedunculi teretes, 10-15 mm. longi, gemmae non visae. Fructus pedicellati, globulari-truncati vel fere rotundi, tenues, glauci, glabri vel minute rugosi 6-10 x 6-10 mm. foraminibus contractis; capsulae 3-1-oculares,. Profunde inclusae.

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By W. F. Blakely, National Herbarium, Sydney.
(Communicated by J. M. Black.)

[Read October 8, 1936.]

**E. gongylocarpa,** sp. nov., "Marble Gum."

Arbor 30-45 pedes (ca. 9-13 m.) alta, ramulis, foliis, fructibus maxime glaucis. Folia juvenilia opposita, subamplexicaulia, sessilia vel breviter petiolata, ovata vel oblonga, crassa, glauca, 2-5 cm. longa, 2-4 cm. lata; folia matura petiolata, alterna necnon opposita, oblongo-lanceolata vel falcato-lanceolata, 4-6 cm. longa, 1-2 cm. lata; venae obscurae, venae laterales irregulares, angulo 30-35 graduum a costa media divergentes, vena intramarginalis a crasso margine remota; umbellae axillares, sub-deflexae, 3-9-florae vel floribus pluribus passim praeditae; pedunculi teretes, 10-15 mm. longi, gemmae non visae. Fructus pedicellati, globulari-truncati vel fere rotundi, tenues, glauci, glabri vel minute rugosi 6-10 x 6-10 mm. foraminibus contractis; capsulae 3-1-oculares, profunde inclusae.

A tree 30 to 45 feet high (Helms); on sand formation, 50 to 80 feet high (Spencer). Branchlets, leaves and fruits very glaucous. Juvenile leaves opposite, subamplexicaul, sessile to very shortly petiolate, ovate to oblong, thick, very glaucous, 2-4 x 2-5 cm. Mature leaves petiolate, alternate and opposite, oblong-lanceolate to falcate-lanceolate, moderately thick, 4-6 cm. long or longer, 1-2 cm. broad; veins indistinct, the lateral ones irregular, diverging at an angle of 30-35° from the midrib; intramarginal vein very undulate and distant from the slightly thickened margin; petioles 5-10 mm. long, usually compressed. Umbels axillary, slightly deflexed, 3-9 flowered or more; peduncles terete, 10-15 mm. long; buds not seen. Fruit on slender, terete pedicels 4-6 mm. long, globular-truncate to almost round, rather thin, very glaucous, smooth or minutely wrinkled, 6-10 x 6-10 mm. contracted at the orifice and completely enclosing the three-celled capsule, the disc forming a slightly undulate annulus around the orifice. The calycine ring of the very young fruit is usually furnished with four microscopic teeth, and it is slightly broader in the centre of the space between each tooth-like projection.

*South Australia*—Mueller and Tate, Proc. Roy. Soc. S. Aust., vol. xvi, p. 358, record a "variety with ovate leaves, 25 miles S.S.W. of Mount Watson." It seems to be the juvenile state of the species.

*Northern Territory*—Between Bagot's Creek and Lake Amadeus, Baldwin Spencer, Horn Expedition, 1894. In the desert country (from the George Gill Range to Ayers Rock and Mount Olga), at p. 81 of the Horn Expedition Narrative, Prof. Baldwin Spencer says, "All the morning we were traversing low sandhills, on many of which grew a fine sandhill gum, *E. eudesmioides*, which reached a height of 50 to 80 feet. The trunk is silver-grey in colour and very shiny, except the butt, where is it covered with a paper-like bark which peels off in long, yellow-brown scales. The grey-green foliage usually forms a kind of umbrella-shaped mass, and it is somewhat strange to find a big tree like this right out amongst the

waterless sandhills." In L. C. E. Gee's "General Report on Tanami Goldfield and District," S.A. Parliamentary Paper, p. 6, 1911, from Tanami to Mucka on the Victoria River, Desert Gums were encountered—probably referable to this species.

*Western Australia*—The following specimens were collected on the Elder Exploring Expedition by R. Helms. Barrow Range, Victoria Desert, Camp 38, "30 to 45 feet high; sandy habitat, 2/9/1891." Victoria Desert, Camp 45, "20 to 35 feet; on sand, 8/9/1891." "The fine growth of *Eucalyptus eudesmioides* (Desert Gum), extending for over 100 miles, gave the country a very pleasing aspect." Vicinity of Queen Victoria Spring, Camp 60, "30 to 40 feet high; sand formation, 24/9/1891." The Type.—It is readily distinguished from *E. eudesmioides* F. v. M., with which it has been confused, by its much larger size, ovate to oblong juvenile leaves, very glaucous and narrower mature leaves with longer petioles, multiflowered umbels, and in the globular or marble-like, very glaucous fruits.

### **E. papuana** F. v. M., var **Aparrerinja** var. nov.,

"Ghost Gumtree" or "White-wash Gum."

A small to large graceful tree, with a smooth white bark, deciduous to the ground, the surface covered with a fine white substance which retards excessive evaporation from the chlorophyll-laden bark beneath and which is used by the blacks as a powder or pigment in various ways. Juvenile leaves opposite for a large number of pairs, elliptical to oblong-lanceolate, pale green, sessile to shortly petiolate, the petioles swollen at the base, venulose, subhispid, the midrib very prominent on both surfaces, 6 to 10 cm. long, 2 to 3·3 cm. broad. Mature leaves alternate, narrow-lanceolate to falcate-acuminate, sometimes very irregular in shape due to insectival action, 10-15 x 1-1·5 cm., the somewhat irregular venation more or less distinct. Inflorescence terminal, forming short panicles or abbreviated cymes of 3-9 flowers; buds shortly pedicellate, pyriform, 6 x 6 mm., the operculum patelliform, much shorter than the calyx, covered with a minute scurfy layer. Fruit brevipedicellate, campanulate, broader than long, 8 x 10 mm., thin, with a broad orifice, and a deeply enclosed trilocular capsule.

*C.A.-N.T.*—Deep Well Station, Charlotte Waters, A. M. Kleining, 20/1/1925; Crown Point and Cunningham's Gap; Ross River Gorge, "Along the river bed were giant gum trees, while one, the most beautiful and graceful of its kind, bearing the unprosaic but descriptive name of White-wash Gum, clings to the rock faces, its dazzling white trunk and bright green foliage standing out against the blue sky and the red rocks." Professor Baldwin Spencer, in "Sydney Sun," 12/9/1923; near Temple Bar, L. K. Ward; Gosse Range, S.W. Macdonnell Ranges; "Aparrerinja" or "Ghost Gumtree," Dr. H. Basedow. Borroloola, large tree; white stem, G. F. Hill. Professor Baldwin Spencer, in "Across Australia," gives an excellent photograph of "White-wash Gum," and on page 151 he says: "This tree is characteristic of the Steppes. The trunk owes its colour to the presence of a perfectly white dust which comes off when rubbed by the hand; in fact, the natives actually use it to whiten their head-bands. We have never seen any trunk to equal this in its intense whiteness." And on page 176 he again refers to it:—"*E. terminalis* grows right on the ranges, and, with its dazzling white trunk, forms a very characteristic feature of the vegetation." It has been referred to by various authors as *E. terminalis*, a species with a rough, persistent bark and long cylindroid-urceolate fruits. Its intense white, powdery bark, abbreviated inflorescence, pyriform buds, and broad campanulate fruits separate it from the species. It seems to have a predilection for quartzite rocks, and should

be a very useful tree for hot, dry, low-rainfall areas. Its flowering period is somewhat irregular, owing to climatic conditions, and ranges from August to January, so far as observed.

### E. trivalva, sp. nov., "Victoria Spring Mallee."

Nihil de statura, facie vel habitu huius Mallee adhuc accurate compertum est.

Ramuli glabri, nitidi, pallidi; folia matura alterna, petiolata, angusto-lanceolata vel lato-lanceolata, crassa, indistincte grisea, 6-9 cm. longa, 2-3 cm. lata; venatio obscura, venae laterales tenuissimae, angulo 40-50 graduum a costa media prominente divergentes, vena intramarginalis juxta marginem crassum nervosum; petioli sub-compressi, 10-17 mm. longi, umbellae 3-8-florae vel multi-florae, pedunculi compressi, 8-10 mm. longi, gemmae non visae.

Fructus flavidi, sessiles, turbinati, truncati, crassi, 7 x 7 mm., discus latus introrsum alte obliquus capsulam 3-locularem angustam occludens, valvae, tres, latae, firmae, sub-exsertae.

Size and habit unknown; branchlets smooth and shining, pale-coloured; mature leaves alternate, petiolate, narrow to broadly lanceolate, thick, dull grey on both surfaces or somewhat subglaucous, 6-9 cm, long, 2-3 cm. broad, venation obscure, the lateral veins very fine and rather close, diverging at an angle of 45-50° from the prominent midrib; intramarginal vein close to the thick nerve-like margin; petioles slightly compressed, 10-17 mm. long. Umbels 3-8-flowered or more; peduncles compressed, broad at the top, 8-10 mm. long; buds not seen. Fruit yellowish, sessile, turbinate, truncate, thick, 7 x 7 mm., the rather broad disc deeply internally oblique, partly concealing the somewhat narrow 3-celled capsule, and the three strong, broad, conspicuous valves which are slightly exsert.

Only known from south of Queen Victoria Spring, Western Australia, R. Helm's No. 28, Elder Exploring Expedition, September, 1891.

The very pale-coloured leaves and fruits are reminiscent of *E. pallidifolia* and *E. confluens*, but the fruits are entirely different to either species, and seem to belong to Series Dumosae. In the absence of complete material it is difficult to assign its true position, and for the present it is placed near *E. dumosa* A. Cunn.

### E. leptophylla, F. v. M., var. floribunda, var. nov. "Flowery Mallee."

A Mallee, 20 feet high in granite formation (R. Helms). Branchlets slightly glaucous; leaves oblong-lanceolate to lanceolate, uncinate, pale coloured, 4-5·5cm. x 1 cm. Flowers very numerous, buds cylindrical; operculum conical, twice the length of the calyx-tube. Fruit pyriform-truncate, 4 x 4 mm. The fruits are figured in Crit. Rev., pt. xiv, pl. 62, fig. 17, as *E. uncinata, Western Australia* —Mount Churchman, about 50 miles north-west from Knutsford, Elder Exploring Expedition, R. Helms, December 10, 1891. The main points which distinguish it from the species are the much shorter and broader leaves, longer operculum, smaller fruits, and subglaucous branchlets. It is a very floriferous variety and in full bloom in December.

### E. oxymitra, sp. nov., "Sharp-capped Mallee."

Arbuscula "Mallee" valde glauca; folia alterna, petiolata satis lato-lanceolata, uncinata, crassa, coriacea ad 7 cm. longa, 2-4 cm. lata; venatio obscura, venae laterales rectae, numerosae, a costa media angulo 30 graduum divergentes; petioli firmi, 10-15 mm. longi. Umbellae axillares, 3-7-florae, gemmae pedicellatae, globulari-rostratae, 10-12 mm. longae, 7-8 mm. diametro,

calycis tubus brevis vix 3 mm., operculum 7-9 mm. longum, rectum subulatumve, ad medium rostratum, antherae "platyantherae," a latere poris magnis orbicularibus aperientes.

Fructus pedicellati, glauci, subglobosi, 11 x 11 mm., discus latus, semi-conicus, truncatus, quam pars calycina minor, valvae 3-5 ligneae, deltoideae, exsertae.

A very glaucous Mallee, size and habit unknown. Leaves alternate, petiolate, somewhat broadly lanceolate, acute or uncinate, tapering abruptly into the slightly compressed petioles, thick, coriaceous, up to 7 cm. long, 2-4 cm. broad; venation obscure, the lateral veins straight and numerous, diverging at an angle of 30° from the midrib; petioles firm, 10-15 mm. long. Umbels axillary; peduncles compressed, robust, with a disc-like expansion at the top, bearing 3-7 shortly pedicellate flowers. Buds somewhat globular-rostrate, 10-12 mm. long, 7-8 mm. in diameter, the calyx-tube very shallow, barely 3 mm., the operculum 7-9 mm. long, straight or subulate-rostrate for half its length. Anthers Platyantherae, broader than long, opening laterally in large orbicular pores, the connective broad with a small terminal gland, and the filament attached at its base. Fruit pedicellate, glaucous, subglobose, 11 x 11 mm., the disc broad, semi-conical, truncate, smaller than the calycine portion, valves 3-5, ligneous, deltoid, exsert.

*Central Australia*—Sandhills near junction of Palmer and Walker; Missionary Plain by Pine Point, Professor Ralph Tate, Horn Expedition, 1894, recorded as *E. Oldfieldii* F. v. M. It is allied to *E. Drummondi* and *E. Lane-Poolei,* but nearest the latter in the sculpture and size of the fruit.

*E. orbifolia* F. v. M. On Mount Sonder, Central Australia, Ralph Tate, 1894; specimen in the University of Adelaide Herbarium. It is recorded in the "Report of the Horn Expedition," p. 159, as *E. Oldfieldii,* var., "with leaves oval-oblong to ovate-obcordate, one to one-and-a-quarter inches long." Previously only known from about 30 or 40 miles north of Southern Cross, Western Australia. It resembles *E. Websteriana* Maiden in the leaves, but differs from it in the striate operculum, and in the large conical, truncate capsular disc.

I wish to express my indebtedness to Mr. J. M. Black, Miss Constance Eardley, Curator of Herbarium, The University of Adelaide, and to Mr. F. J. Kae, Government Botanist, Victoria, for the loan of specimens.

## Abstract of New Species.

The species are from the arid regions of Central and Western Australia, and belong to Series Eudesmieae, Dumosae, and Leptopodiae, respectively. *E. gongylocarpa* is allied to *E. eudesmioides* F. v. M., from which it is readily distinguished by its multiflowered umbels and round marble-like fruits. *E. trivalva* has the characteristic pale leaves and fruits of *E. confluens,* and *E. pallidifolia,* but on the available evidence it is placed near *E. dumosa* A. Cunn., while *E. oxymitra,* a small glaucous Mallee, somewhat resembles *E. Lane-Poolei* Maiden in its floral and carpological characters.

# ON MAMMALS FROM THE LAKE EYRE BASIN. PART III. THE DIPROTODONT MARSUPIALS AND ORNITHODELPHIA.

*BY W. F. BLAKELY*

**Summary**

*Macropus rufus* (Desmarest); (Koongarra: of the Wonkonguroo) . The red kangaroo occurs sparsely over the whole of the Basin, but is dispersed for the most part in small bands or even as individuals. It is highly migratory and nomadic, however, and here, as elsewhere in the Centre, shows an astonishing faculty, almost a prescience, for discovering and concentrating upon areas which have been favoured by rain or local flood.

# ON MAMMALS FROM THE LAKE EYRE BASIN. PART III.

## THE DIPROTODONT MARSUPIALS AND ORNITHODELPHIA.

By H. H. Finlayson.

[Read October 8, 1936.]

### Macropodinae.

*Macropus rufus* (Desmarest); (Koongarra; of the Wonkonguroo).

The red kangaroo occurs sparsely over the whole of the Basin, but is dispersed for the most part in small bands or even as individuals. It is highly migratory and nomadic, however, and here, as elsewhere in the Centre, shows an astonishing faculty, almost a prescience, for discovering and concentrating upon areas which have been favoured by rain or local flood.

In December, 1931, small parties of it were sighted at a distance on several occasions, both on Sturt's Stony Desert and in the white sandhill country of the Barcoo and Strzelecki (both very forbidding areas even at that time), but it is doubtful whether in a normal dry year it would tolerate the very severe summer conditions of the gibber plains and sandhills for long. As a minor factor tending to mitigate the conditions in these types of country, must be mentioned the artesian bore streams, brought to the surface at a time when the economic possibilities of the country were rated much higher than now, but still gushing out millions of gallons of potable water into the empty wilderness which the desertion of the holdings has recreated. The area influenced by the bores is, of course, very small, but it is probable that they are the means of retaining small numbers of kangaroos in districts which would otherwise be completely deserted by them, except in rain time; *M. rufus* being one of the few marsupials which easily becomes addicted to regular and copious drinking if water is available.

The only locality in which large numbers were observed was on the Providence Creek, east of Sturt's Stony Desert and near the western boundary of Cordillo sheep run, which at that time was almost unstocked. The lower course of the creek had been flooded three weeks previously, and kangaroos were on all the green flats thereabouts and watering even in broad daylight at the pools in the channel.

I have not applied a subspecific name to the local kangaroo, since but two specimens of it were got, and in an animal exhibiting extraordinary individual variation, such differentiation calls for a wealth of material. Some pure red-coated individuals were seen (and a very dark plumbeous phase on Cordillo), but a large proportion of those observed (and the two females collected) were in an intermediate blue-red phase, such as commonly occurs at this time or a little later on the saltbush tablelands in South Australia, between lats. 30-34° south. For reasons already noted, the presence of *M. rufus* in those portions of the Lake Eyre Basin, which have imposed subspecific differences upon resident mammals, is but spasmodic and transitory, and if one may accept the validity of the three described races of the red kangaroo, there is little doubt that the form here noticed is reconcilable with the eastern race *M. rufus typicus* (Desm.).

Flesh dimensions of (1) a very aged female, (2) a yearling female, taken near Tcherrikooninyee water, on a gibber plain, 15 miles east of Appamunna:—

Head and body, 964; 627. Tail, length[1] 926; 668. Tail, girth at base 340; —. Chest girth, 460; —. Manus length, 70; 43. Nail of 3rd digit, 19; 13. Pes length, 318; 258. 4th toe, 125; 95. Nail of 4th toe, 28; 19·5. Ear, 137 x 50; 110 x 50. Rhinarium to eye, 102; 70. Eye to ear, 62; 50. Eye (intercanthus), 28; 21. Weight, 73 lbs; 21 lbs.

Skull dimensions of the above aged female:—Greatest length 178, basal length 165·5; greatest breadth, 93·0; nasals greatest breadth, 28·5; nasals least breadth, 18·6 ea.; nasals length, 79·0; intertemporal breadth, 23·0; palate breadth inside $M^2$, 32 (ca.); palate length, 110·5; diastema, 48·1; basicranial axis, 43 (ca.); basifacial axis, 126 (ca.); facial index, 293 (ca.); $M^1$-$M^3$, 30; ant. palatal foramina, 13·5.

*Other Macropodinae.*

On the eastern and western margins of the Basin the uniformity of the gibber plains is broken by firm rangelets, which provide a suitable environment for *Macropus robustus* and *Petrogale* spp., and the accounts given by cattlemen testify to the former presence of both in these localities. The testimony of the blacks of the area about the two rivers on this point is surprisingly vague, and except that a wallaby-like animal, called karndoo by the Dieri, is found in hills far to the north-east, I was not able to gather from them any information, and material is quite lacking.

On the western side, in the Peake and Mount Margaret Ranges, the two species may be set down with probability as *M. robustus erubescens* and *Petrogale xanthopus typicus,* although the most northerly records of these two species in South Australia is provided by specimens taken by the writer near Mount Norwest in the Willouran Hills, 170 miles south-east of Mount Margaret. There is just a possibility, however, that the rock wallaby in these hills may have been *P. lateralis,* the southerly record of that species being near Morilyanna,[2] 250 miles north-west.

On the eastern side also *M. robustus erubescens* and *P. xanthopus* are no doubt responsible for the accounts of euros and rock wallabies; the latter possibly *P. xanthopus celeris* of Le Souef, the type of which came from the head of the Bulloo Creek, 250 miles north by west of Cordillo.

At the time of the taking of the first specimen of *Caloprymnus* in 1931, there were reasons for suspecting the presence in the same districts of a species of *Lagorchestes,* probably *L. hirsutus,* which, though predominantly a western species, ranges on the Tropic to at least 136° E. longit. Its presence in the Lake Eyre Basin, now appears doubtful, however. No specimens have been obtained in the five years that have elapsed, and repeated questioning of the blacks has narrowed their accounts of animals resembling *Caloprymnus* to the kanunka, which is evidently of the Potoroinae. There is still, of course, the account given by Mr. J. N. McGilp (vide Le Souef and Burrel, "The Wild Animals of Australia," p. 214) of a small "hare wallaby" near Lake Frome on the southern fringe of the area here dealt with. This was considered by Le Souef to be *L. hirsutus,* and certainly the account of its behaviour when chased would support that identification.[3] *L. conspicillatus,* which in slightly higher latitudes ranges from the east coast almost to Gibson's Desert, is also apparently absent.

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(1) Flexed at right angles to trunk.

(2) Somewhat further to the west, it is reported from localities considerably further south, but there is no material in support as yet.

(3) Mr. McGilp has since had an opportunity of inspecting skins of all the related forms, and is now doubtful on this point.

Finally, in connection with this subfamily, should be noticed the statement of Sturt (Expedition into Central Australia, vol. ii, appendix) that an animal silvery grey in colour and crossed with dark bars on the back (and, therefore, strongly suggestive of *Lagostrophus fasciatus)* was seen on the "plains of the Interior," and that the same animal was common north of Gawler.

## POTOROINAE.

*Caloprymnus campestris* (Gould).

Since my last reference to this animal (Trans. Roy. Soc. S. Aust., 1932, p. 148-167) I have examined five more specimens which have been taken in the same area since that time, and through the kindness of Mr. Reese, frequent reports have come to hand regarding the movements of the oolacunta in his country and that of his neighbours. Though it is still present in the area from which the series came in 1931, it is now almost as scarce there as before that time, and from Cooncheri Flats, which seemed to be its headquarters then, it has evidently disappeared. On the other hand, in 1933-34 it had a time of plenty at Mulka, and it was frequently seen at Ooroowillanie as late as 1935. On the whole, the records to hand suggest that *Caloprymnus* participates in the north to south drift which seems to characterise all the small mammals here after a favourable season, though in this case the drift is evidently much slower than with other species.

In the matter of proving the extension of its range outside the Lake Eyre Basin, little progress has been made. To the east, the enquiries of M.C. John Finn amongst settlers has produced only negative results, but in the west there is now no doubt that it was well established as far out as Ediacra (20 miles west of Farina) in 1886, though it is many years since it was seen there. On the Nullarbor the position is still obscure, but its former presence there seems less improbable than it did in 1931. It transpires that the weelba (or wilba) of the Banda Plateau blacks, which is the subject of the sand hill legend quoted *(loc. cit.)*, is not an entirely mythical animal, but was known in the flesh beyond the period of white occupation. Moreover, Mr. Bolam has given an account of a nest-building animal on the plain in 1912, and of the blacks' method of taking the same, which tallies well with what I have recorded for *Caloprymnus* on the Diamantina. He reaffirms, too, that the name weelba was used by the Fowler's Bay natives for this nest-building animal. In all these accounts, however, the possibilities of confusion with *Choeropus, Bettongia* and *Lagorchestes* are so great that nothing short of specimens from the area will clarify the position. It should be recorded here that the old collection of the S.A. Museum contains an unlocalized skull upon which is pencilled *"Bettongia campestris."* It has no history, unfortunately, but as some other skulls in the Museum are from Tate's collection, it is possible that this is a relic of his journey to the head of the Bight in 1878. It is the skull of *B. lesueuri.*

One of the specimens referred to above was an adult male, and though in alcohol and strongly contracted, some of its flesh dimensions may be quoted here as amplifying the data of Table I in my former contribution *(loc cit.)*. Head and body, 322; tail, 380; pes, 119; 4th toe, 52; nail of same, 17; ear, 41; rhinarium to eye, 34; eye to ear, 25.

Skulls of two other large and fully adult males gave dimensions exceeding those formerly quoted, and closely paralleling those of the type male. Flesh dimensions of these two males are not available, but it now seems improbable that the female attains to larger dimensions than the male.

The skull of the larger of the two males gives the following values. Greatest length, 68·3; basal length, 57·6; zygomatic breadth, 41·2; nasals length, 32·0;

nasals greatest breadth, 21·2; nasals least breadth, 8·5; nasals overhang, 5·8; depth anterior nares, 15·6; constriction, 15·5; palate length, 35·4; palate breadth inside $M^2$, 12·5; ant. palatine foramina, 4·3; diastema, 8·8; basicranial axis, 19·6; basifacial axis, 39·4; facial index, 201; $M^{s\,1-3}$, 12·6; $P^4$, 5·6.

All efforts to obtain other members of the subfamily have failed, but the Wonkonguroo who now live along the lower course of the Diamantina tell of a "kanunka" which lives in the very arid districts which they have vacated. Their accounts suggest *Bettongia lesueuri*, but if it is so, it is curious that it should be absent from the Lake Eyre Basin, since it thrives in equally poorly vegetated areas to the north, west and south. In these districts its warrens betray it, but I have seen none such in the Basin, and it is evidently not represented in the contiguous tracts of South-west Queensland, since Longman does not list it in his 1930 list.

### Phascolomyidae.

Though no wombat now lives within the area, and their warrens were not seen, the family is listed here to draw attention to the interesting statement of Sturt [4] (generally overlooked) as to their former presence between the Barrier and Grey Ranges, upon what might be regarded as its south-eastern border. Early in December, 1844, during a time of hot winds, Sturt records that "the dogs took shelter in wambut holes"; and as he must have been familiar with the burrows and dung of both species in the south, there is no reason to doubt the accuracy of his identification. Dr. Macgillivray, of Broken Hill, N.S.W., some ten years ago provided confirmation of the former presence of wombats in the same area by the discovery of incisors in superficial deposits there.

### Phalangeridae.

*Trichosurus vulpecula* (Kerr); (Unta).

The brush-tailed opossum is the only member of this family the presence of which is attested by positive evidence. It is well known to all the native groups of the two rivers. Unlike its kindred in the western Centre, it appears never to leave the main channels of these two streams, where eucalypts provide it with the environment familiar in the coastal districts. On the lower course of the Diamantina it is evidently now almost a rare animal, and several natives who have been encouraged by Mr. Reese to seek it in the channels of the Diamantina, between Goyders Lagoon and the Queensland border, have not only failed to secure specimens, but report that no traces of it can now be found there. It is said to be more plentiful on the Cooper above Innamincka, but the only material I have examined is a skin and skull of an aged male taken by Waite in 1917 between Kuttapiric Point and Innamincka. Size about as in *eburacencis*, considerably smaller than in the south. Dorsal pelage very short and colour much lighter than normal in individuals from southern South Australia, and considerably lighter than the average pelage which prevails over west Central Australia; the general colouration suggesting *eburacencis* or even *arnhemensis*. On the nape and shoulders, however, the basal colour is a rather rich brown, which shows through on the surface of these parts and in diluted form is suffused over the whole of the dorsum. The colour is more uniformly spread than in any opossum I have examined save *johnstoni*, and it confers on the entire pelage a decided vinaceous cinnamon tint, the more apparent from the virtual absence of black guard hairs. Ventrum pale vinaceous cinnamon basally, cream terminally, the midline from the rich brown sternal gland patch to scrotum brownish gold, quite

(4) Exped. into Central Australia, **vol. i**, p. 197.

different from the dorsal colours. Manus, pes, ear and tail about as in *eburacencis*.

Skull:—Greatest length, 78; basal length, 70·6; zygomatic breadth, 51·1 ca.; nasals greatest length, 29·0; nasals greatest breadth, 15·1; intertemporal constriction, 8·8; palate length, 40·5; palate breadth (inside $M^2$ ant. angle), 15·1; anterior palatal foramina, 6·3; $P^4$, 4·1; $M^{s\,1\text{-}3}$, 12·3.

If the colouration described is constant, this form would apparently rank as a rather well-defined geographical race, easily distinguished from its allies in neighbouring areas. Colour aberations in *Trichosurus* are too frequent and the treatment to which the above skin has been submitted, too uncertain, however, to justify publishing a name for this single specimen.

### Ornithodelphia.

*Echidna aculeata* (Shaw), (inappa, or inniwallinga of the Wonkonguroo) occurs in the area but cannot be said to be a common animal, since men of 30 years' experience of the country have never seen one. Most reports of it are from stony country, particularly the hills on Cordillo in the north-east of the tract. It is not altogether absent from the sandhills, however, and its tracks were seen in April, 1934, and June, 1935, between Appamunna and Pandi, but no specimens have come to hand.

Reports of the sporadic occurrence of *Ornithorynchus* in the Diamantina and Barcoo and other east central rivers, may be attributed with probability to *Hydromys*.

# ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA NO. 34.

*BY J. M. BLACK, A.L.S.*

## Summary

Spikelets 1-flowered, usually in pairs or threes along the rhachis of spike-like racemes, 1 sessile, bisexual and fertile and 1 or 2 pedicellate, male or neuter; glumes of fertile spikelets usually 4, the third one small and hyaline, the fourth or flowering glume small, narrow and usually awned.

# ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA

## No. 34.

By J. M. Black, A.L.S.

[Read October 8, 1936.]

Plate XVI.

### Gramineae.

### Tribe **Andropogoneae.**

Spikelets 1-flowered, usually in pairs or threes along the rhachis of spike-like racemes, 1 sessile, bisexual and fertile and 1 or 2 pedicellate, male or neuter; glumes of fertile spikelets usually 4, the third one small and hyaline, the fourth or flowering glume small, narrow and usually awned.

A. Spikelets all alike in sex.
  B. Racemes in spikelike compound silky panicles; all spikelets pedicellate and bisexual; flowering glume awnless .. .. .. .. *Imperata* 1
  B. Racemes digitate; spikelets in pairs; flowering glume 2-toothed at tip and awned between the teeth .. .. .. .. .. .. *Eulalia* 2
A. Spikelets of each pair differing in sex, the sessile one fertile, the pedicellate one neuter or rarely male, those at the summit of the racemes arranged in threes; rhachis of the racemes or panicle-branches articulate.
  C. Racemes in a loose panicle without spathes; pedicels without a translucent groove; awn rising between the 2 terminal teeth of the flowering glume; pedicellate spikelets awnless.
    D. Racemes with the lower spikelets mostly in pairs; outer glume finally hardened .. .. .. .. .. .. .. .. *Sorghum* 3
    D. Racemes or panicle-branches bearing only 3 terminal spikelets; outer glume membranous .. .. .. .. .. .. *Chrysopogon* 4
  C. Racemes not arranged in a loose panicle; outer glume of sessile spikelet flat or concave, 2-keeled near the incurved margins, the 2nd glume about as long, usually 3-nerved, with a blunt protuberant keel and enclosing the narrow awned flowering glume; racemes more or less digitate along the primary rhachis of a rather dense simple rarely compound panicle; pedicels and articles of rhachis villous; 1 or 2 of the lowest sessile spikelets in each raceme male or neuter and awnless, although resembling the fertile sessile spikelets.
    E. Awn rising from the toothless summit of the short linear flowering glume.
      F. Pedicels and articles of rhachis with a longitudinal translucent furrow .. .. .. .. .. .. .. *Bothriochloa* 5
      F. Pedicels and articles of rhachis opaque .. .. .. *Dichanthium* 6
    E. Awn rising from the toothless summit of the short linear flowering glume; pedicels and articles opaque. Racemes in pairs at the end of short branches, with a spathe or long sheathing bract permanently supporting each pair, the whole forming a long leafy false panicle .. .. .. .. *Cymbopogon* 7

1. *Imperata cylindrica* (L.) Beauv.—Throughout Australia; also southern Europe and Asia.

2. *Eulalia fulva*, O. Kuntze (1891); *E. Cumingii* (Nees) A. Camus (1922); *Saccharum fulvum*, R. Brown (1810) *Pollinia Cumingii* Nees (1855); *P. fulva* (R. Br.) Benth. (1878) non Sprengel (1815).—Throughout Australia; also India.

*Eulalia* is rather narrowly distinguished from *Pollinia* by the silky-haired spikelets and narrower leaves.

*3. *Sorghum halepense* (L.) Pers. "Johnson Grass." — *Andropogon halepensis* (L.) Brot. An escape in all the States.

4. *Chrysopogon Gryllus* (L.) Trin.—*Andropogon Gryllus,* L.—Northern part of South Australia, and all other States except Victoria and Tasmania; also southern Europe and Asia.

5. *Bothriochloa,* O. Kuntze (1891). (From Greek *bothrion,* a little pit; *khloê,* grass = *Amphilophis,* Nash (1901).

The basal sessile barren spikelets in *Bothriochloa* and *Dichanthium* persist at the summit of the stem some time after the upper spikelets have fallen.

Nodes glabrous; pedicellate spikelets neuter, with usually only 1 glume; anthers purple; racemes usually 2-5 .. .. .. .. .. *B. decipiens* 1
Nodes more or less pubescent; pedicellate spikelets sometimes male, with usually 3 glumes; anthers yellow; racemes 7-22 .. .. .. .. *B inundata* 2

1. *B. decipiens* (Hack.) C. E. Hubbard in Kew Bull., 10:444 (1934). Perennial, glabrous except inflorescence; stems slender, usually reddish-purple, 40-80 cm. high; nodes glabrous; leaf-blades usually flat, about 3 mm. broad; panicle erect, simple 4-8 cm. long; racemes 2-5, rarely 6 to 8; 3-6 cm. long, sub-digitate, shortly pedunculate, white-silky by the long hairs of the joints of the rhachis and the pedicels; primary rhachis $1\frac{1}{2}$-2 cm. long; sessile spikelet lanceolate, 6-7 mm. long, including the short, bearded callus; outer glume flattish, more or less channelled, glabrous or with scattered hairs on lower part of back, 5-7-nerved between the two ciliolate keels, with a usually deep pit above the middle, forming a boss on the inner face, or unpitted, or with a shallower inconspicuous pit only near the base; second glume white, boat-shaped, 3-nerved; third glume flat, hyaline, nerveless, 3-4 mm. long, ciliate in upper part; flowering glume about 3 mm. long, supporting a brown awn 17-20 mm. long; anthers narrow, $1\frac{1}{2}$-2 mm. long, purple; pedicellate spikelets narrow-linear, 4-6 mm. long, neuter, usually consisting of only one glume, which is 7-nerved between the keels, rarely with a second smaller hyaline glume. (Pl. xvi, fig. 6.)—*Andropogon pertusus* (L.) Willd. var. *decipiens,* Hack. (1889); *A. decipiens* (Hack.) Domin (1915); *A. pertusus,* Benth. (1878) non Willd.

South Australia.—Bremer Ranges near Woodchester, *T. G. B. Osborn;* north of Saddleworth, *A. J. Adams;* Bordertown, per *G. H. Clarke.* Apparently rare here.—Northern and eastern Victoria; New South Wales, westward to Riverina; Queensland. Called in the Eastern States "Red Leg" or "Red Grass," on account of the usually red colour of the stem, and is considered a good fodder, at least in its early stages.

2. **B. inundata** (F. v. M.) nov. comb. Nodi plerumque pubescentes; panicula simplex, sericea, 6-10 cm. longa, racemis 7-22, $2\frac{1}{2}$-5 cm. longis, quam rhachis primaria longioribus; antherae flavae; pedicellatae spiculae saepius 3-glumes, nonnunquam masculae.

Stems glabrous except the inflorescence, 30-80 cm. high, usually stout; some or all the nodes appressed-pubescent; leaves glabrous, except that the base of the lower sheaths is usually silky, and the orifice of the sheaths is mostly villous, the blades flat, 3-5 mm. broad; panicle 6-10 cm. long, simple; racemes more or less erect, 7-22, $2\frac{1}{2}$-5 cm. long, silky from the long hairs on the joints of the rhachis and the pedicels; primary rhachis $1\frac{1}{2}$-$3\frac{1}{2}$ cm. long, shorter than the racemes; sessile spikelet lanceolate, 4-5 mm. long, including the bearded callus; outer glume glabrous or with a few scattered hairs on lower half, 5-7-nerved between the two ciliate keels, sometimes faintly 1-pitted near the summit; second glume boat-shaped, 3-nerved, ciliate; third glume hyaline, nerveless, ciliate, about 3 mm. long; flowering glume linear, 2-$2\frac{1}{2}$ mm. long, with an awn 15-25 mm. long; anthers 2 mm. long, yellow; pedicellate spikelets neuter or rarely male, linear lanceolate,

3-5 mm. long, the outer glume glabrous on back, 7-9-nerved between the ciliate keels; second glume 3-4 mm. long, hyaline, 3-nerved, ciliate; third glume 2-3 mm. long, hyaline, nerveless, ciliate, or absent; a grass growing near water.—*Andropogon inundatus,* F. v. M. in Linnaea 25:444 (1852); *A. intermedius,* Benth. Fl Aus. 7:531 (1878) pro parte non R. Br.; *Amphilophis intermedia* (R. Br.) Stapf in Agric. News, W. Indies 15:179 (1916) var. *pabularis,* Stapf.

South Australia.—Mount Lyndhurst, *Max Koch;* Crystal Brook, *F. v. M.* (type); Toorawatchie Waterhole (between Cordillo Downs and Cooper's Creek), *J. B. Cleland;* Callana (Lake Eyre Basin), *M. Murray;* Depot Creek (east of Lake Torrens), *R. Tate.* Described by Koch as good fodder.

*Central Australia.*—Finke River; south of George Gill Range; Alice Springs; Burt's Well; MacDonald Downs; Darwent Creek; Cockatoo Creek; Mount Liebig.

Differs from *Andropogon intermedius,* R. Br. *(Bothriochloa intermedia)* in the panicle subdigitate and always simple and in the pubescent nodes; from *Amphilophis glabra* (Roxb.) Stapf *(B. glabra),* in the primary rhachis shorter than the racemes, the panicle not compound and much shorter. The latter species occurs in Queensland and New South Wales.

## 6. Dichanthium, Willemet.

(From Greek *dikha,* apart, different, and *anthos,* flower.)

Stems 30-70 cm. high; racemes 3-5 cm. long, densely silky; outer glume of sessile spikelets 4-5 mm. long, 5-7 nerved, densely bearded near summit by an arch of long hairs; awn 25-33 mm. long; outer glume of pedicellate spikelets 7-13-nerved, the 3rd glume usually present .. *D. sericeum* 1

Stems 10-30 cm. high; racemes 1½-2 cm. long, with shorter hairs; outer glume of sessile spikelets 4 mm. long, 3-5-nerved, villous along the margins; awn 20-22 mm. long; outer glume of sessile spikelets 7-9-nerved, the 3rd glume absent .. .. .. .. .. .. *D. humilius* 2

1. *D. sericeum* (R. Br.) A. Camus in Bull. Mus. His. Nat. Paris 27:549 (1921).—*Andropogon sericeus,* R. Br. Prodr. 201 (1910). (Pl. xvi, fig. 2.)

South Australia.—Sturt River, near Brighton; Watervale; Depot Creek, near Lake Torrens; Swallow Waterhole, near Oodnadatta; Strangways Springs; Lake Frome; Cordillo Downs; Diamantina River; Strzelecki Creek.

Central Australia.—Finke River; Alice Springs; Irukaru Creek.

Also New South Wales, Queensland and Western Australia.

2. **D. humilius,** nov. sp. Gramen humile, 10-30 cm. altum, nodis patente breviterque albo-barbatis, culmis gracilibus; foliorum vaginae glabrae, rarius sparsim tuberculatae, laminae inferne planae, 2-3 mm. latae, glabrae vel pilis ex tuberculis ortis conspersae; ligula truncata, circa 1 mm. longa, ciliata; racemi 2-6, digitati, sessiles, villosi sed minus dense quam in *D. sericeo,* 1½-2 cm. longi (absque aristis); spiculae sessiles oblongae, truncatae, 4 mm. longae (cum callo barbato); gluma exterior 3-5-nervis inter duas carinas ciliolatas, dorso fere glabra, pilis longis suberectis sed non arcuatim dispositis marginata; secunda gluma fere aequilonga, 3-nervis; tertia gluma minuta, hyalina enervis vel nulla; florifera gluma lineari-lanceolata, 2 mm. longa, in aristam 20-22 mm. longam desinens; spiculae pedicellatae obovato-oblongae, circa 3 mm. longae; gluma exterior 7-9-nervis inter carinas, pilis ut in spicâ sessili dispositis; secunda gluma circa dimidio brevior, hyalina, 3-5-nervis, marginibus incurvis ciliata; tertia gluma nulla; caryopsis obovata, 2 mm. longa. (Tab. xvi, fig. 3.)—*Andropogon annulatus,* Forsk. var. (?) *humilis,* Benth.

South Australia.—Near Oodnadatta, *Miss Staer;* Snake Gully, Pedirka, *E. H. Ising;* Lake Frome, *S. A. White;* Diamantina River, *J. B. Cleland.*

Central Australia.—Charlotte Waters, *E. Giles.*

Differs from *D. annulatum* (Forsk.) Stapf in the shorter stature and shorter racemes, the nerves of the outer glume of the sessile spikelets fewer, the back much less hairy, the pedicellate spikelets always neuter and their third glume wanting.

The specimens from Charlotte Waters, kindly lent for examination by the Victorian National Herbarium, are those on which Bentham founded his var. *humilis*.

Owing to the existence of *Andropogon humilis*, Hochst and *A. humilis*, Wight I have slightly altered Bentham's varietal name.

## 7. Cymbopogon.

(From Greek *kymbos*, hollow, alluding to the spathes, and *pôgôn*, beard.)

Racemes more or less erect; awns conspicuous, about 15 mm. long; leaf-blades inrolled, filiform .. .. .. .. .. .. *C. exaltatus* 1

Racemes, or most of them, finally reflexed; awns inconspicuous, 5-8 mm. long, or absent; leaf-blades flat .. .. .. .. .. .. *C. bombycinus* 2

1. *C. exaltatus* (R. Br.) Domin (1915). "Scented Grass."—*Andropogon exaltatus*, R. Br.

South Australia.—Gorges of Torrens and Little Para Rivers; Mannum; Flinders Range, from Crystal Brook northward; Andamooka; Strzelecki Creek; Everard and Musgrave Ranges.

Central Australia.—Alice Springs; Mount Liebig; Undoolya; Ayer's Rock; Hermannsburg; Mount Ultimo.—Also New South Wales, North and Western Australia.

2. *C. bombycinus* (R. Br.) Domin (1915).—*Andropogon bombycinus*, R. Br.

South Australia.—Torrens Gorge; Black Hill; Lyndoch Valley; Murtho (River Murray); near Everard and Musgrave Ranges.

Central Australia.—Alice Springs; Barrow's Creek.—Also western New South Wales and Queensland; Western Australia.

*Agrostis avenacea*, J. F. Gmel. (1791). Dr. T. A. Sprague, of Kew Herbarium, states, in reply to a question, that he considers this is the valid name for *Avena filiformis*, G. Forst. (1786). The name *Agrostis filiformis* (Forst.) Spreng. (1807) is illegitimate because of the prior *Agrostis filiformis* Vill. (1787), which is a different species. In the same way *Calamagrostis filiformis*, Cockayne (1908) and Pilger (1921), is illegitimate on account of another species which was given the same name by Grisebach in 1868. Dr. Sprague places this grass in *Agrostis* because "it has all the characters of that genus, whilst the hairy prolongation of the rhachilla and the short-bearded callus are to be found in a number of African and Indian species of *Agrostis*." At the same time he envisages the possibility that a revision of the group might show that *Avena filiformis*, which was described from plants collected by Forster in New Zealand and Easter Island, is a distinct species from *Agrostis retrofracta*, Willd. (1809), which was described by Willdenow from plants collected in Australia.

If the opinion is followed that species with a short tuft or beard on the callus, the hairs of which do not exceed about one-quarter of the length of the flowering glume, should be placed in *Agrostis*, our other species, at present considered as belonging to *Calamagrostis* section *Deyeuxia*, would be named as follows:—*Agrostis aequata*, Nees; *A. quadriseta*, R. Br.; *A. Billardieri*, R. Br.; *A. plebeia*, R. Br.; *A. minor* (Benth.) nov. comb.; *A. densa* (Benth.) F. v. M. *Calamagrostis* would then be confined to extra-Australian grasses with beards almost equalling or exceeding the flowering glume.

*Triodia pungens*, R. Br. Koontarra Soak, west of Cleland Hills, Central Australia, January, 1935, *H. H. Finlayson*. Panicle to 25 cm. long; spikelets

12-14 mm. long, mostly 9-flowered; outer glumes $5\frac{1}{2}$ mm. long, 7-nerved; flowering glumes $6\frac{1}{2}$ mm. long; central lobe 3 mm. long, two lateral lobes 2 mm. long, all very acute and 3-nerved.

### Cyperaceae.

*Lepidosperma concavum*, R. Br. Kirton Point, Port Lincoln, *J. M. Black*. A first record for Eyre Peninsula.

### Proteaceae.

*Grevillea Wickhamii*, Meissn. Alice Springs, Central Australia. Received per J. E. L. Machell.

### Santalaceae.

*Anthobolus exocarpoides*, F. v. M. Cleland Hills, Central Australia, January, 1935, *H. H. Finlayson*. "Over 1 m. high; fruits red." The succulent exocarp dries orange.

### Nyctaginaceae.

*Boerhavia repanda*, Willd. Between Middleton Ponds and Liddle's Hills, Central Australia, June 17, 1935, *J. B. Cleland*. This appears to be the first record for Central Australia.

### Chenopodiaceae.

*Arthrocnemum halocnemoides*, Nees, nov. var. **pterygospermum.** Seminis testa concentrice pluricostata, costis tenuibus, pinniformibus, suberectis, subundulatis, multis lineis crebris transversis notatis. (Tab. xvi, fig. 7.)

The seed of this plant, collected by Miss C. M. Eardley on Mount Victor Station, near Koonamore, in May, 1936, appears to be nearest to that of var. *pergranulatum*, the concentric rows of tubercles of the latter being replaced by concentric fin-like ribs marked with numerous fine transverse lines.

### Amaranthaceae.

**Amaranthus grandiflorus,** nov. comb. Herba annua glabra, 15-30 cm. alta, caule erecto rigidulo ramoso; folia ovato-lanceolata, longe petiolata, 2-3 cm. longa; flores in glomerulos mox dense congregati; perianthii feminei segmenta 5, ovato-oblonga, mucronata, demum superne patentia, 5-6 mm. longa, breviter unguiculata; perianthii masculi segmenta 5, lanceolata, $2\text{-}2\frac{1}{2}$ mm. longa, exunguia; fructus indehiscens, transversim rugosus, ovoideus, perianthio paulo brevior; styli et stamina 3; semina nigra, nitentia, 2 mm. longa. (Tab. xvi, fig. 4.)—*A. Mitchellii*, Benth. var. *grandiflorus*, J. M. Black in Trans. Roy. Soc. S. Aust., 47: 368 (1923).

South Australia.—Between Morgan and Renmark, *Gross;* near Mount Lyndhurst, *J. B. Cleland;* Mount Parry, *R. Tate;* Frome Downs, *T. B. Paltridge;* Pernatty, *B. J. Murray*.

Central Australia.—Finke River, *H. H. Finlayson;* west of Erldunda, *J. B. Cleland*.

This now seems to me worthy of specific rank. Differs from *A. Mitchellii* (pl. xvi, fig. 5) in the female perianth segments twice as long, with a short claw and ovate-oblong lamina, instead of a claw about as long as the fan shaped lamina, the flower-clusters larger and denser, the fruit transversely rather than vertically furrowed, and the seeds larger.

### Phytolaccaceae.

*Gyrostemon australasicus* (Moq.) Heimerl. Sandhills near Koontarra Soak, west of Cleland Hills, Central Australia, January, 1935, *H. H. Finlayson*. Similar to the North Australian specimens mentioned by Mueller and Bentham, with very

narrow leaves ($\frac{3}{4}$-1 mm. broad); anthers 8-9, obtuse, whereas in southern specimens they number 8-13 and appear acute, owing to the deltoid membranous extension of the connective above the cells. No female flowers have been collected with specimens from North or Central Australia, so that some uncertainty exists.

### Aizoaceae.

**Cryophytum nodiflorum* (L.) L. Bolus. Salt Swamps, Port Pirie. Previously found near Port Germein.—South Africa.

### Leguminosae.

*Acacia retivenea,* F. v. M. Fragm. 3: 128 (1863). Cleland Hills and Blood's Range, Central Australia, January, 1935, *H. H. Finlayson.* "1½-2 m. high." First record for Central Australia and for extra-tropical country; hitherto found at Short's Range, north of Tennant's Creek, North Australia, and at Margaret River, north-west part of Western Australia. Phyllodes obliquely obovate, coriaceous, 3-5 cm. long, 2-3½ cm. broad, with 4-5 prominent curved nerves confluent at base; petioles stout, 2-5 mm. long; heads globular, 70-80-flowered, on stout axillary twin or solitary peduncles 10-25 mm. long and exceeding the upper diminished floral leaves, so that the inflorescence appears paniculate; calyx 2 mm. long, divided from about the middle into five hairy spathulate lobes; corolla 3 mm. long, densely hairy on the five short lobes; pod still unknown.

Bentham Fl. Aust. 2: 392 (1864) altered the specific name to *retivenia,* but, under Art. 70, Mueller's spelling must be restored.

*Acacia minutifolia,* F. v. M. Robert Range, Western Australia, February, 1935, *H. H. Finlayson.* Phyllodes obliquely obovate or oblong, thick, 2-2½ mm. long, obscurely 2-3-nerved, mucronulate on the upper angle; buds narrowly conical. New for Western Australia.

*Kennedya prorepens,* F. v. M. Blood's Range, Central Australia, January, 1935, *H. H. Finlayson.* "Low creeper in creek." The flowers are arranged in few distant clusters of 2-3, forming a narrow raceme about 3 cm. long, the naked part of the peduncle rather longer. The standard bears two oblong calli above the claw; ovules seven in each of three ovaries examined; stipules ovate-lanceolate, about 4 mm. long; stipellae caducous.

**Trifolium Cherleri,* L. Beaumont (near Adelaide), November, 1934, *J. B. Cleland.* This species, distinguished by sessile caducous flower-heads, which are surrounded at base by the large orbicular stipules of the small floral leaves, is a native of the Mediterranean region. Differs from *T. striatum* in the heads globular, not ovoid; the uppermost stipules (sometimes without leaflets) rounded at summit, not pointed; the calyx-teeth erect and about twice as long as the tube, instead of the teeth somewhat spreading and only equalling the tube. A new introduction.

### Meliaceae.

*Owenia reticulata,* F. v. M. Near the Granites, Central Australia, *J. B. Cleland.*

### Euphorbiaceae.

*Euphorbia Stevenii,* Bailey. Specimens collected on the flood-plain of the Diamantina in August, 1934, by Prof. J. B. Cleland show that the seed is at first white and granular or almost smooth, but that when ripe it has a dark-brown testa covered with minute whitish tubercles and is ovoid or almost globular in shape and 3½-4 mm. long.

STACKHOUSIACEAE.

*Macgregoria racemigera,* F. v. M.—Near Coniston Station, Central Australia, *E. C. Black.* These little plants, with their masses of white blossoms, are said to resemble snow on the ground.

STERCULIACEAE.

*Melhania incana,* Heyne. Reefs near Wytookarri Rock Hole (between Cleland Hills and Blood's Range), Central Australia, January, 1935, *H. H. Finlayson;* "40 cm. high." The petals are not, as stated by Bentham, persistent, but form a tubular calyptra round the ovary and then fall off.

MYRTACEAE.

*Eucalyptus gracilis,* F. v. M. Near Mylor; December, 1935; *C. D. Boomsma.* First record from the Mount Lofty Range; the mallee form and numerous. The inflorescence agrees exactly with dry-country specimens, but the leaves are broader (1-2½ cm. broad near base) and without the black dots. These variations are probably due to the moister climate.

*E. brachycalyx,* Blakely, Key Euc. 119 (1934). Differs from *E. dumosa* in the buds rather shorter, 7-8 mm. long, ovoid-oblong, instead of cylindrical, more or less ribbed, distinctly pedicellate, with a ribbed obtuse cap almost as long as the receptacular part; fruit turbinate, sometimes almost smooth, 5-7 mm. long, about 6 mm. broad, the valves sometimes protruding; leaves narrow, shining, 15 mm. broad or less, rarely more; small tree or mallee, 3-8 m. high, with smooth white bark except at the base.

Murat Bay and north thereof; near Moolooloo (Flinders Range). The native name at Murat Bay is gheelya (gilja).

Var. *chindoo,* Blakely l.c. Differs chiefly in the fruit, which is turbinate or almost globular- truncate, smooth or almost so, 5-6 mm. long, the valves with protruding points.—*E. incrassata,* Labill. var. *protrusa,* J. M. Black, pro parte.

Murat Bay; Minnipa; between Whyalla and Iron Knob, Eyre Peninsula; Mannum.

The cotyledons are reniform. Both the species and the variety appear endemic to South Australia.

*E. largiflorens,* F. v. M. (1854). Dr. T. A. Sprague, one of the leading authorities on nomenclature, states in reply to a question, that in his opinion the description of *E. bicolor,* A. Cunn. (1848) is not a valid one. (See Fl. S. Aust., 416.)

UMBELLIFERAE.

**Bifora testiculata,* DC. A weed at Riverton, *Worsley C. Johnston.*—Mediterranean region. A new introduction.

PLUMBAGINACEAE.

**Statice psiloclada,* Boiss. Salt marsh, Port Pirie.

BORRAGINACEAE.

**Halgania glabra,** nov. sp. Frutex glaber (absque staminibus), viscidus, circa metralis; folia integra vel rarius superne obsolete denticulata, lanceolata vel oblongo-cuneata, in petiolum brevem angustata, supra concavula, 1-3 cm. longa, 3-9 mm. lata; flores 5-8 in quoque pedunculo, superiores solitarii, distantes, inferiores bini vel trini; pedicelli graciles; calyx 7-9 mm. longus, segmentis linearibus, obtusis; corolla 10-12 mm. longa; antherae pilis brevibus deflexis puberulae, loculis 4 mm. longis, rostro 3 mm. longo; fructus immaturus emargina-

tus, oblongo-cuneatus, circa 6 mm. longus, in dua carpella biloculata discedens. (Tab. xvi, fig. 1.)

Blood's Range, Central Australia, January, 1935, *H. H. Finlayson.* Differs from other described species in being glabrous, except the anthers. It is perhaps nearest to *H. littoralis,* Gaudich. var. *glabrifolia,* Benth. *(H. Bebrana,* F. v. M.) and *H. Gustafsenii,* F. v. M., but differs in its viscid and glabrous character, the leaves shortly petiolate and usually quite entire, and (as regards *H. Bebrana)* the beak shorter than the anther-cells; also perhaps in the inflorescence, which appears to be largely racemose.

SOLANACEAE.

*Solanum hystrix,* R. Br. Specimens from near Koonibba, Eyre Peninsula, collected in May, 1935 and 1936, by J. S. Foggo, show that the berry is depressed-globular, 2-3 cm. diam., yellowish-green until ripe, drying dark-brown or purple, at first enclosed in the calyx, later protruding from it. According to Mr. Foggo, sheep and cattle like the fruit, and the natives scrape out the fleshy part and eat it.

## Nicotiana.

Dr. Helen-Mar Wheeler has published, in the University of California Publications in Botany, vol. xviii (1935), the result of a revision of the Australasian species of *Nicotiana,* undertaken in collaboration with Professor T. H. Goodspeed. Not only were the collections in many herbaria studied, but most of the species were grown from Australian seed in the congenial climate of California. Altogether 15 species are described, including one from New Caledonia and the Tonga Islands.

In Australian species of *Nicotiana* the corolla, calyx and pedicels are always more or less pubescent, even if the rest of the plant is glabrous. The limb of the corolla closes under a hot sun and opens about sunset, when a usually rather faint perfume is emitted. The limb is always white, but the tube may be purplish or yellowish-green. The root often appears perennial, but my experience with three species grown in the garden is that they are annual. The margin of the leaves is usually more or less wavy.

The following key to our South Australian species, one introduced and one Central and Western Australian growing near our border, is chiefly based on that of Dr. Wheeler.

A. All stamens with filaments of equal length, affixed near base of corolla. Glabrous shrub; calyx 10-12 mm. long, with very short teeth; corolla yellowish, its tube about 30 mm. long by 5 mm. diam.; limb short, suberect; filaments about 20 mm. long; leaves ovate-lanceolate, on long slender wingless petioles .. .. .. .. *N. glauca* 1

A. Four stamens on short filaments affixed near summit of corolla-tube, the 5th filament longer and affixed lower down, but its anther not reaching the same level as the others; hairs, when present, with minute globular or sometimes discoid heads (except in *N. occidentalis);* corolla-limb spreading, white; herbs.

  B. Stem-leaves decurrent by 2 broad wings, glabrous or almost so, ovate-lanceolate to obovate, 5-30 cm. long, 2-15 cm. broad, often denticulate on margin, corolla-tube about 50 mm. long, 4-5 mm. diam.; 5th filament affixed about middle of tube .. .. .. *N. excelsior* 2

  B. Stem-leaves not or scarcely decurrent.

    C. Stem-leaves sessile, broad at base.

      D. Plant pubescent all over with short hairs, many of them clavate (ellipsoid headed); stem-leaves mostly 3-8 cm. long, 1-2 cm. broad, broadly lanceolate, subacute, half-clasping, the basal ones narrowed downwards; flowers distant; calyx campanulate, about 10 mm. long, the teeth usually shorter than tube; corolla tube about 20-40 mm. long, 4-5 mm. diam. near mouth, tapering downwards; 5th filament short, affixed in upper half of tube; capsule about as long as calyx .. .. .. .. *N. occidentalis* 3

D. Plant woolly all over with longer hairs, which mostly terminate in minute globular heads; stem-leaves obovate-oblong, shortly acuminate, sometimes fiddle-shaped, half-clasping by 2 broad auricles, 5-20 cm. long, 2-12 cm. broad, the basal ones small, fugitive, oblong, with winged petioles; flowers crowded in terminal panicles; calyx 16-24 mm. long, the lanceolate teeth as long as or longer than tube; corolla-tube 30-50 mm. long, about 4 mm. diam., cylindrical; 5th filament affixed at or below middle of tube; capsule shorter than calyx .. .. .. *N. Gossei* 4

C. Stem-leaves not sessile, narrowed towards base or petiolate.

E. Corolla-tube 3 5 mm. diam., suddenly widened where it emerges from calyx, the 5th filament usually affixed below middle of tube; plants pubescent on stem-leaves, the basal ones forming a rosette on the young plant, leaves oblanceolate to obovate; calyx teeth shorter than or as long as tube.

F. Leaves 3-12 cm. long, 1-8 cm. broad, the stem-leaves tapering into a narrowly winged petiole; whole plant softly pubescent; flowers racemose or paniculate; calyx 8-12 mm. long; corolla-tube 14-25 mm. long, capsule nearly as long as calyx .. .. .. .. .. .. .. .. *N. velutina* 5

F. Leaves 3-25 cm. long, 2-10 cm. broad, more or less pubescent, with petioles broadly winged and those of the stem-leaves often half-clasping at base; calyx 10-20 mm. long; corolla-tube 18-22 mm. (rarely to 28 mm.) long; capsule about equalling calyx .. .. .. .. .. *N. maritima* 6

E. Corolla-tube slender, $1\frac{1}{2}$-$2\frac{1}{2}$ mm. diam.

G. Leaves and stems glabrous or almost so; flowers sparsely pubescent; leaves oblanceolate, mostly 4-15 cm. long, 1-5 cm. broad, tapering into narrowly winged petioles, the radical ones in a basal rosette and usually broader than the stem-leaves; calyx-teeth shorter than tube.

H. Calyx 12-17 mm. long, 10-ribbed; corolla-tube 30-50 mm. long, tapering gradually downwards; 5th filament affixed near middle of tube; capsule almost cylindrical, 10-13 mm. long .. .. .. .. *N. ingulba* 7

H. Calyx 7-10 mm. long; corolla-tube 14-20 mm. long; 5th filament affixed in lower half of tube; capsule 7-10 mm. long, oblong-ovoid .. .. .. .. *N. Goodspeedii* 8

G. Leaves and stems pubescent or woolly with glistening spreading hairs; leaves ovate or oblong to almost orbicular, obtuse or subacute, with winged petioles, the stem leaves few, sometimes oblanceolate; calyx 6-11 mm. long, with linear teeth nearly as long as tube; corolla tube 13-21 mm. long $1\frac{1}{2}$ 2 mm. diam. the 5th filament affixed at or below middle of tube; capsule narrow-oblong, usually 7-8 mm. long .. .. .. .. .. *N. rotundifolia* 9

*1. *N. glauca*, Graham. The "Tree Tobacco" was first noticed in Australia about 1860 as an immigrant from Argentina. Now common in many places.

2. *N. excelsior*, J. M. Black in Trans. Roy. Soc. S. Aust., 50:286 (1926). Erect, 1-2 m. high, branching in upper part of stem.—*N. suaveolens* var. *excelsior*, Black in Trans. Roy. Soc. S. Aust., 39:835, tt. 63 and 70 (1915); *N. macrocalyx*, Domin in Bibl. Bot. Heft 89:1147, t. 36 (1929).

South Australia.—Birksgate Range, *R. Helms;* Everard Range, *S. A. White;* Musgrave Ranges, *J. B. Cleland;* Mann Range, *Tindale* and *Hackett.* Leaves chewed by natives as a narcotic. Names recorded in our North-West: Kâman, okiri, pulanda, mingul, mingurpa and ingulba. It is certain that at least some of these names are applied to various masticated species.

3. *N. occidentalis*, Wheeler in Univ. Calif. Publ. Bot. 18:52 (1935); Black in Trans. Roy. Soc. S. Aust., 59:260, t. 4, fig. 3 (1935). About 20-50 cm. high, the short spreading hairs conspicuous on all parts of plant, the floral bracts usually longer and more leafy than in other species.

South Australia.—Musgrave Ranges, *J. B. Cleland;* Pundi Soak, 40 miles south of Musgrave Ranges, *H. H. Finlayson.*

Central Australia.—Mount Peake, *J. C. Chandler.*

Western Australia.—Add to localities quoted by Dr. Wheeler: Victoria Desert, September 15, 1891, *R. Helms.*

4. *N. Gossei,* Domin, in Bibl. Bot., Heft 89: 1146, t. 36 (1929). About 50 cm.- 1 m. high, with numerous spreading-erect branches and a bushy appearance. Chewed by natives, at least in the Musgrave Ranges, and called mingul, mingulba and pituri. (Pl. xvi, fig. 8.)

South Australia.—Ernabella, Musgrave Ranges, *J. B. Cleland.* Also in Central Australia.

5. *N. velutina,* Wheeler l.c. 55 (1935).

South Australia.—Mount Parry Gap, *R. Tate;* Copley, *W. A. Cannon;* Blinman and Wilmington, *E. H. Ising;* Petermorrow Springs, *S. A. White;* Diamantina River, *L. Reese;* Alberga Creek, *S. A. White;* Macumba River, *J. B. Cleland;* Mount Gunson Mine, *Mrs. Beckwith;* Spalding, *J. M. Black;* Ooldea, *N. B. Tindale.* The specimens from Ooldea have corollas more slender than usual.

Central Australia.—Erldunda, Hermannsburg and Alice Springs, *J. B. Cleland;* Horse-shoe Bend, Finke River, *E. H. Ising.*

Also in western New South Wales and south-west Queensland.

6. *N. maritima,* Wheeler l.c. 56 (1935).

South Australia.—Dudley Peninsula, K.I., *R. Tate;* Granite Island, *E. H. Ising;* Waterfall Gully, Inman Valley, Hallett's Cove, *J. B. Cleland;* Mount Brown, *R. Tate;* Kinchina, *E. H. Ising;* Port Noarlunga, Port Willunga, Mount Ferguson, Telowie Gorge, Woolshed Flat and Stansbury, Yorke Peninsula, *J. M. Black.* Dr. Wheeler also quotes specimens from Port Augusta, Georgetown and Coffin Bay, Eyre Peninsula.

These two species (Nos. 5 and 6) are nearly allied and sometimes show a tendency to run into one another.

The true *N. suaveolens,* Lehmann appears to be confined to eastern New South Wales and eastern and central Victoria. The name was applied by Bentham, Fl. Aust. 4: 469 (1869), to all the then known Australian species.

7. *N. ingulba,* J. M. Black in Trans. Roy. Soc. S. Aust., 57: 156, t. 9 (1933). Stems rather slender. The names ingulba and mingurpa (probably dialectic variants) are used by the natives for more than one species whose leaves are chewed.

Central Australia.—Chambers Pillar, *R. Tate;* between Finke River and Charlotte Waters, *H. Kempe;* Harper's Spring, *Kramer;* Middleton's Ponds and Mount Liebig, *J. B. Cleland;* Horseshoe Bend and Macdonald Downs, *E. H. Ising.*

Western Australia.—Mount Squires and Victoria Desert, *R. Helms.*

8. *N. Goodspeedii,* Wheeler l.c. 63 (1935).

South Australia.—Fowler's Bay, *Mrs. Richards* (co-type in Tate Herbarium); Ooldea, *J. B. Cleland;* Mannum, *R. Tate;* north of Wilmington, *E. H. Ising;* Overland Corner, Loxton, coast near Adelaide and Port Hughes, Yorke Peninsula, *J. M. Black.*

New South Wales.—Dr. Wheeler quotes the Ivanhoe district, to which may be added: Coonamble, Narrabri, Gunnedah, *J. B. Cleland.*

9. *N. rotundifolia,* Lindley in Bot. Reg. Misc. 59 (1838). Sometimes flowering in a raceme, or only 1-flowered when the plants are small.

South Australia.—Oratunga and Moolooloo, *E. H. Ising;* Oodnadatta to the Musgrave Ranges, *J. B. Cleland.*

Central Australia.—Heavitree Gap (MacDonnell Ranges), *J. B. Cleland.* Also in Western Australia.

## Labiatae.

*Microcorys Macreadieana,* F. v. M. Between Middleton Ponds and Liddle's Hills, Central Australia, June 18, 1935, *J. B. Cleland.* Resembles our Broombush *(Baeckea Behrii),* but the leaves are more slender and in whorls of three.

## Verbenaceae.

*Spartothamnus teucriifolia,* F. v. M. Ten and thirty miles north-east of Ayers' Rock, Central Australia, June, 1935, *J. B. Cleland.* Some of the lower flowers are 2-3 on a short common axillary peduncle, the upper ones are solitary in the axils of leafy bracts, which are caducous; the two small bracteoles at the base of the pedicel are persistent.

## Goodeniaceae.

*Goodenia erecta,* Ewart Fl. N.T., 265, t. 22 (1917). Ayers' Rock, Central Australia, June 4, 1935, *J. B. Cleland.* The type came from about 250 miles further north. The basal and lower leaves are lyrate, 2-3 cm. long, including the slender petiôle, the lanceolate entire bracteoles about as long as the articulate pedicels; the narrow racemose panicles are 8-15 cm. long and the upper peduncles are often only 1-flowered. Each plant has several slender stems, 20-30 cm. high, in our specimens.

## Compositae.

**Chrysanthemum anethifolium* (Willd.) Brouss. Sandhills near Glenelg; Semaphore, Maitland, Yorke Peninsula. An escape from cultivation.—Canary Islands.

**Centaurea nigrescens,* Willd. Millicent, South-East, *E. S. Alcock.* A new introduction.—Southern Europe.

**Tolpis barbata* (L.) Gaertn. Morialta, *J. B. Cleland.* A new introduction. —Mediterranean region.

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## DESCRIPTION OF PLATE.

### Plate XVI.

Fig. 1 *Halgania glabra:—A,* connate anthers and beak; *B,* calyx and fruit.

Fig. 2 *Dichanthium sericeum:*—sessile and pedicellate spikelets and rhachis-joint from which another sessile spikelet has fallen.

Fig. 3 *Dichanthium humilius:*—a similar drawing.

Fig. 4 *Amaranthus grandiflorus:*—fruiting perianth and 1 perianth-segment.

Fig. 5 *Amaranthus Mitchellii:*—fruiting perianth and 1 perianth segment.

Fig. 6 *Bothriochloa decipiens:—C,* upper portion of a raceme; *D,* adaxial face of sessile spikelet, with pedicellate spikelet and rhachis-joint; *E,* back of 1st or outer glume of fertile spikelet; *F,* back of 2nd glume; *G,* 3rd glume and grain.

Fig. 7 *Arthrocnemum halocnemoides* var *pterygospermum:*—seed viewed from the side and cross-section of same.

Fig. 8 *Nicotiana Gossei:—H,* fiddle-shaped stem-leaf; *I,* basal leaf.

# AMPHIPODS FROM A SOUTH AUSTRALIAN REEF.-PART 2.

BY *KEITH SHEARD*

**Summary**

Rostrum strongly curved, reaching to middle of first joint of peduncle. Eyes, contiguous at base of rostrum, the pair together, circular. Sideplate 1 expanded anteriorly and fringed with setae on the anterior lateral margin. Sideplate 2 deeper, only slightly expanded, anterior lateral margin fringed with setae. Sideplate 3 is one and half times as deep as 2, antero lateral angle fringed with short setae. Sideplate 4 deeper than 3 and nearly twice as broad, slightly excavated along the distal margin, antero lateral angle with sparse setae. Sideplate 5 two-thirds as deep as 4, bilobed, with the anterior lobe the larger. Sideplate 6, anterior lobe absent, posterior lobe small, sparsely setose. Sideplate 7 represented by a slight postero expansion of the first joint.

# AMPHIPODS FROM A SOUTH AUSTRALIAN REEF.—PART 2.

By Keith Sheard,
Hon. Assistant in Zoology to the South Australian Museum.

[Read October 8, 1936.]

Plate XVII.

## Family OEDICEROTIDAE Stebb.

### Oediceroides Stebb.

### **Oediceroides pirloti,** sp. n.

Rostrum strongly curved, reaching to middle of first joint of peduncle. Eyes, contiguous at base of rostrum, the pair together, circular. Sideplate 1 expanded anteriorly and fringed with setae on the anterior lateral margin. Sideplate 2 deeper, only slightly expanded, anterior lateral margin fringed with setae. Sideplate 3 is one and half times as deep as 2, antero lateral angle fringed with short setae. Sideplate 4 deeper than 3 and nearly twice as broad, slightly excavated along the distal margin, antero lateral angle with sparse setae. Sideplate 5 two-thirds as deep as 4, bilobed, with the anterior lobe the larger. Sideplate 6, anterior lobe absent, posterior lobe small, sparsely setose. Sideplate 7 represented by a slight postero expansion of the first joint.

Telson cordate in the dorsal aspect, with four setae on each of the lateral margins and two spines on the apex.

First antenna, first joint subequal to second but nearly twice as wide, second four times third, flagellum of 23 joints.

Second antenna, third joint equal to 1 and 2 together, fourth three times and fifth twice as long as the third joint, flagellum composed of many compressed segments.

All mouth parts very small. Mandible, cutting edge a little produced, dentate; secondary cutting edge, right, blade-like with four teeth, left, columnar with 9-10 teeth; spine row with 11-13 long, weak spines; molar strong with margin finely denticulate; palp with first and third joints equal, small, second joint twice first, weakly curved. Maxilla 1 with 8-toothed spines on inner plate, outer with sparse weak setae, palp with spiniform setae on second joint.

Maxilla 2 with inner plate fringed with setae.

Gnathopods 1-2 alike, but first weaker and shorter than second; fifth joint about one-third length of oval sixth, lobe small but reaching to edge of very oblique palm, finger long, curved and slender, palm defined by two stout spines.

Peraeopods 1-2 weak, first with seventh joint apparently absent, second with seventh joint present as a very small finger; fourth joint of both forwardly produced on the posterior margin to a setose lobe. Peraeopods 3-4, second joint expanded, third ringlike, fourth longer than second and more widely expanded, in peraeopod 3 the distal edge is produced to a lobe nearly as long as the fifth joint, in peraeopod 4 this production is much shorter, bilobed; joints 5-6 subequal, the seventh joint is subequal to the fifth, leaf-shaped. Peraeopod 5, more than twice peraeopod 4; second joint sub-circular, third very small, fourth slightly expanded, fourth fifth and sixth joints progressively longer, spined; seventh equal to fifth but one-third as broad.

Uropod 1, outer ramus three-quarters inner, peduncle equal to inner ramus; uropod 2, rami subequal 1, inner equal to peduncle; uropod 3, rami equal, lanceolate, peduncle four-fifths of rami; uropod 1 equal to uropod 3; uropod 2 slightly longer. Uropods lightly spined.

*Locality*—South Australia: St. Vincent Gulf, Sellick's Beach. (Hale, April, 1936.)

Type, female, South Australian Museum. Length, 12 mm.

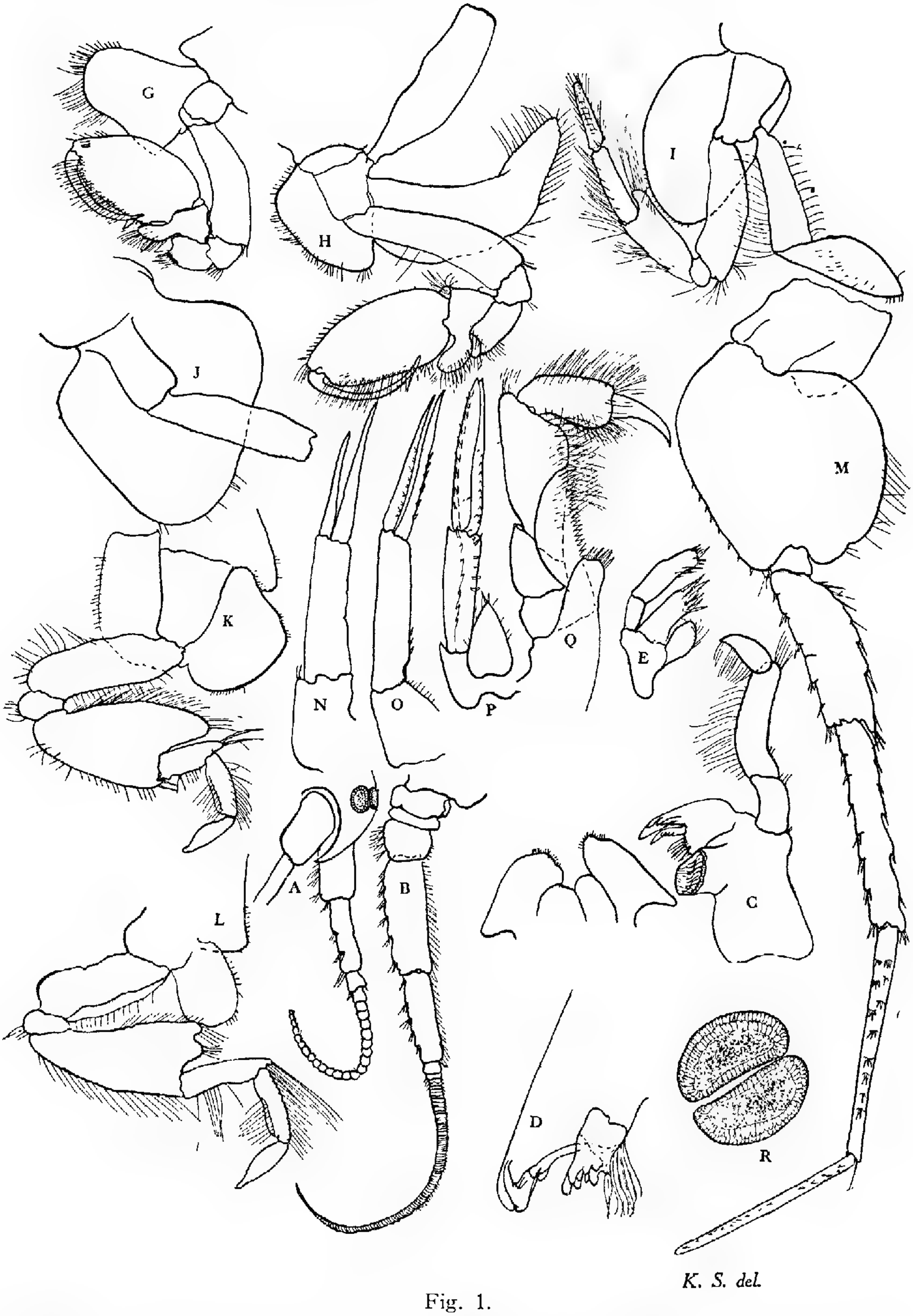


Fig. 1.

*Oediceroides pirloti*, Male—A, antenna 1; B, antenna 2; C, mandible; D, cutting edge left mandible; E, maxilla 1; F, lower lip; G, gnathopod 1; H, gnathopod 2; I, peraeopod 1; J, sideplate, peraeopod 2; K-M, peraeopods 3-5; N-P, uropods 1-3; Q, maxilliped; R, eyes.

Were more specimens of this form available, permitting a comparison of male and female and the mapping of individual variations, it would be possible to fix the generic position of the species more accurately; at present it is placed in Oediceroides Stebb., pending the revision of the southern species of the family. The fine denticulation of the margin of the molar process, the absence of the seventh joint of the first peraeopods, and the wide expansion of the fourth joints of peraeopods 3-4 are points of considerable interest.

The species is named in appreciation of the valuable discussion of Dr. J. M. Pirlot on the relationships of the group to which this family belongs.

### References.

Barnard—Annals South Afr. Mus., **vol. xv,** pt. iii, pp. 162-167, 1916 (and references therein.)

Barnard—Discovery Reports, **vol. v,** pp. 135-141, 1932.

Pirlot—Siboga-Expeditie, Livr, cxvii, pp. 81-99, 107-108, 1932.

The following papers were not available for reference:

Stephensen—The Danish Ingolf Exp., **vol. iii,** No. 11, 1931.

Schellenberg—Furth. Zool. Res. Swed. Ant. Exp, 1901-3, **vol. ii,** No. 6.

## Family AMPITHOIDAE.

### Gen. Grubia Czern.

### **Grubia variata,** sp. n.

Body robust. Sideplates moderately large. Antennae long. Sideplates 1-4 increasingly deeper and broader. Sideplate 1 produced forwards; sideplate 4, the largest, rounded below; sideplate 5 forward lobe square in outline, as deep as 3; sideplates 6-7 very shallow.

Eyes, small, rounded, on lateral lobes.

Antenna 1 with first and second joints subequal, third one-third of second, accessory flagellum of six joints, very slender; flagellum multi-jointed. The antenna is subequal in length to the body.

Antenna 2, extending to fifth peraeon segment; fourth and fifth joints subequal.

Upper lip longer than broad, terminal process furry.

Lower lip with inner lobes bifid, mandibular process relatively large.

Mandible with cutting edge and secondary cutting edge unidentate, spine row of 5-6 weak spines, molar plate large, palp slender, first joint slightly widened, subequal to third in length, second the longest.

Maxilla 1, inner plate, very small with one seta, outer with nine spines, palp, slender, with second joint three times first, tipped with setae. Maxilla 2 with inner edge setose.

Maxilliped with outer plate fringed with many very small teeth, saw like; inner small fringed with long setae; palp with first three joints expanded, third bearing on its distal edge plumose setae, and opposing the fourth joint are two strong setae bearing spines, the fourth joint bears what can best be described as a stout, movable spine.

Gnathopods 1-2 are of the same general pattern with the second joint apically lobed; in gnathopod 2 the fifth joint is produced on its infero distal angle to a setose lobe, and the whole appendage is stouter than the first.

Peraeopods 1-2 with the second joints a little expanded, the fourth joints are the next longest, slightly expanded on the anterior edge. Peraeopod 3 reverted, second joint expanded, joints 3-6 rounded, joint 6 the longest, finger small. Peraeopod 4, second joint moderately expanded, nearly twice as long as

broad, joints 4-5 subequal, joint 6 more than three times joint 3, finger strong. Peraeopod 5 longer than peraeopod 4, joint 6 equal to joint 2 in length.

Uropod 1 the longest, rami subequal, and subequal to the peduncle without its long stout terminal spine; uropod 2 with inner ramus slightly the shorter, both slightly shorter than peduncle; uropod 3 with stout peduncle and equal rami of little more than half its length; the outer ramus on the left side is furnished with two small terminal hooks, that on the right, with one, much stouter. The

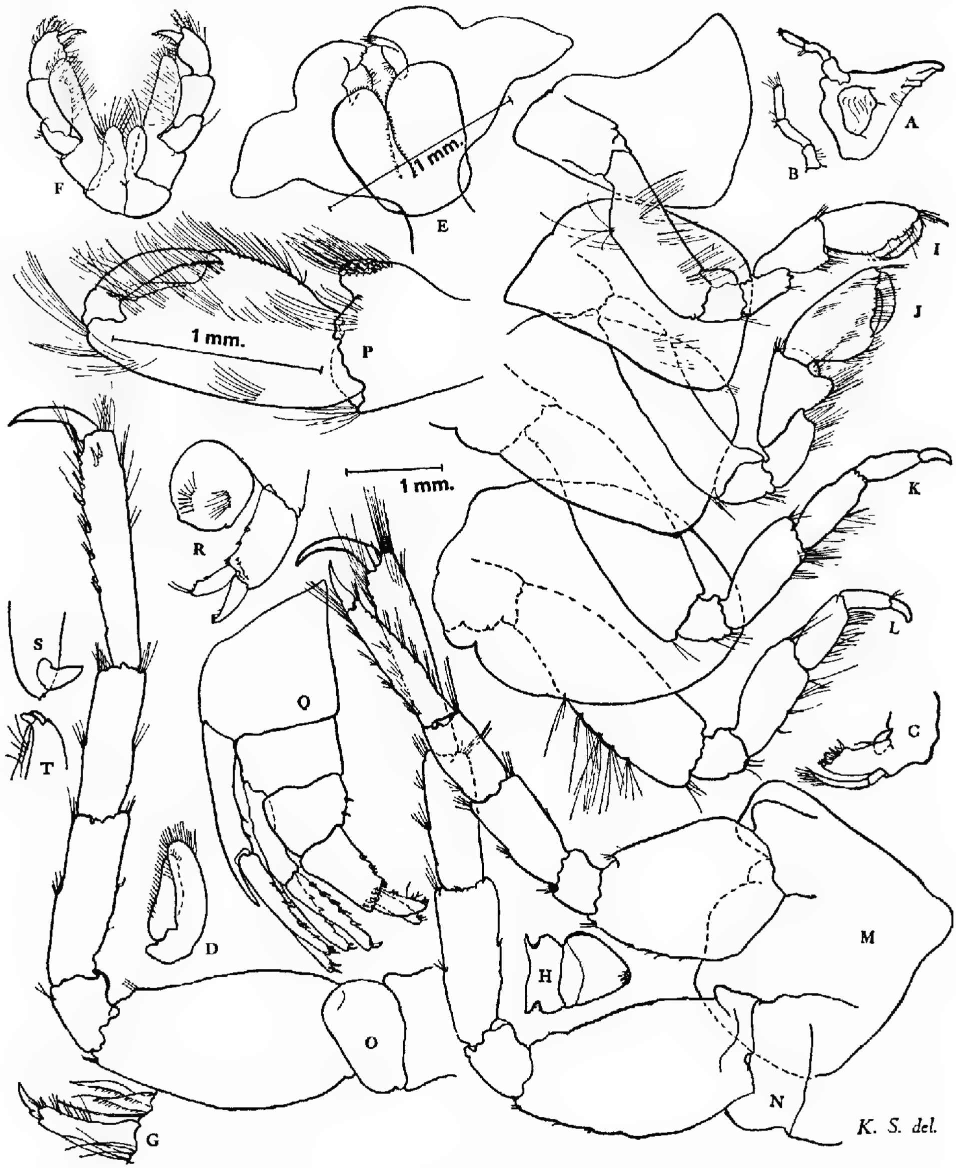


Fig. 2.

*Grubia variata*, Male—A, left mandible; B, palp, right mandible; C, maxilla 1; D, maxilla 2; E, lower lip; F, maxillipeds; G, joint 4 and spine, maxilliped; H, upper lip; I-J, gnathopods 1-2; K-O, peraeopods 1-5; P, terminal joints gnathopods 2; Q, uropods 1-3; R, uropod 3 and telson; S, spine of uropod 3, right; T, spines of uropod 3, left.

uropods are lightly armed with spines. The segment of uropod 3 bears two spines on each side of the dorsal surface.

Telson as broad as long, distal margin well defined, the dorsal surface bears two rows of spine-like setae.

The specimen is only moderately setose.

*Locality*—South Australia: St. Vincent Gulf, Sellick's Beach. (Hale, April, 1936.)

Type, male, South Australian Museum.

The female varies very little from the male, except that peraeopods 1-2 are shorter and more slender. The asymetric arrangement of the hooked spines of uropod 3 is constant in both sexes.

For the present this Amphipod is given specific rank, but it is possible that future collections from Sellick's Beach may result in a series of specimens which may link it more closely with a known form.

It may be distinguished by the six jointed accessory flagellum; the comparative length and expansion of peraeopods 1-2, by the arrangement of the hooks on the third uropods, and by the jointed spine on the fourth joint of the palp of the maxillipeds.

### Reference.

1916 Barnard, Annals S. Afr. Mus., **vol. xv,** pt. iii, p. 257 (and biblio.).

## Family GAMMARIDAE.

### Gen. Ceradocus A. Costa.

### Ceradocus rubromaculatus (Stimps.).

Specimens which must be referred to this cosmopolitan species are very common in the material from Sellick's Reef.

The large male figured is typical of the form obtained, noteworthy being the equally developed second gnathopods, comparatively bare of armature, the downward extension of the second joints of peraeopods three to five and the length of uropod 1 which extends nearly as far as the tip of uropod 3.

The figures given are self-explanatory. Of interest is the varied forms of spines on the inner plate of the first maxilla.

Among the material are specimens of both sexes, evidently in different stages of growth, in which the variations of the proportions and shape of the gnathopods are considerable. It is evident that little reliance can be placed on these as specific characters in such cosmopolitan species. In this regard the work done on Growth Stages of Gammarus (E. W. Sexton, Journ. Mar. Biol. Ass. of the U.K.; n.s. 13, pp. 340-401, 1923-1925) and on Intersexes in Gammarus (Sexton and Huxley, *loc. cit.*, n.s. 12, 1919-1922, pp. 506-556) is of considerable value.

### Reference.

Biol. Res. "Endeavour," **vol. v,** pt. ii, p. 71, Chilton, 1921.

## Family GAMMARIDAE.

### Gen. Maera Leach.

### Maera mastersi (Haswell).

The Sellick's Beach specimens of this species vary slightly from Haswell's description, but not sufficient to warrant the establishment of a new species. As the existing description and figures are somewhat sketchy they are supplemented in this paper.

The variations from Haswell's description are (Compare Das Tierreich, lf. 21, p. 439):—

Accessory flagellum 10 jointed. Peraeopods 4-5 with the front margin of the second joint irregularly spined.

The following additional description is furnished: —

Mandible—Palp slender, second joint four-thirds length of third, cutting edge bidentate, secondary cutting edge quadridentate, molar not denticulate, spine row weak.

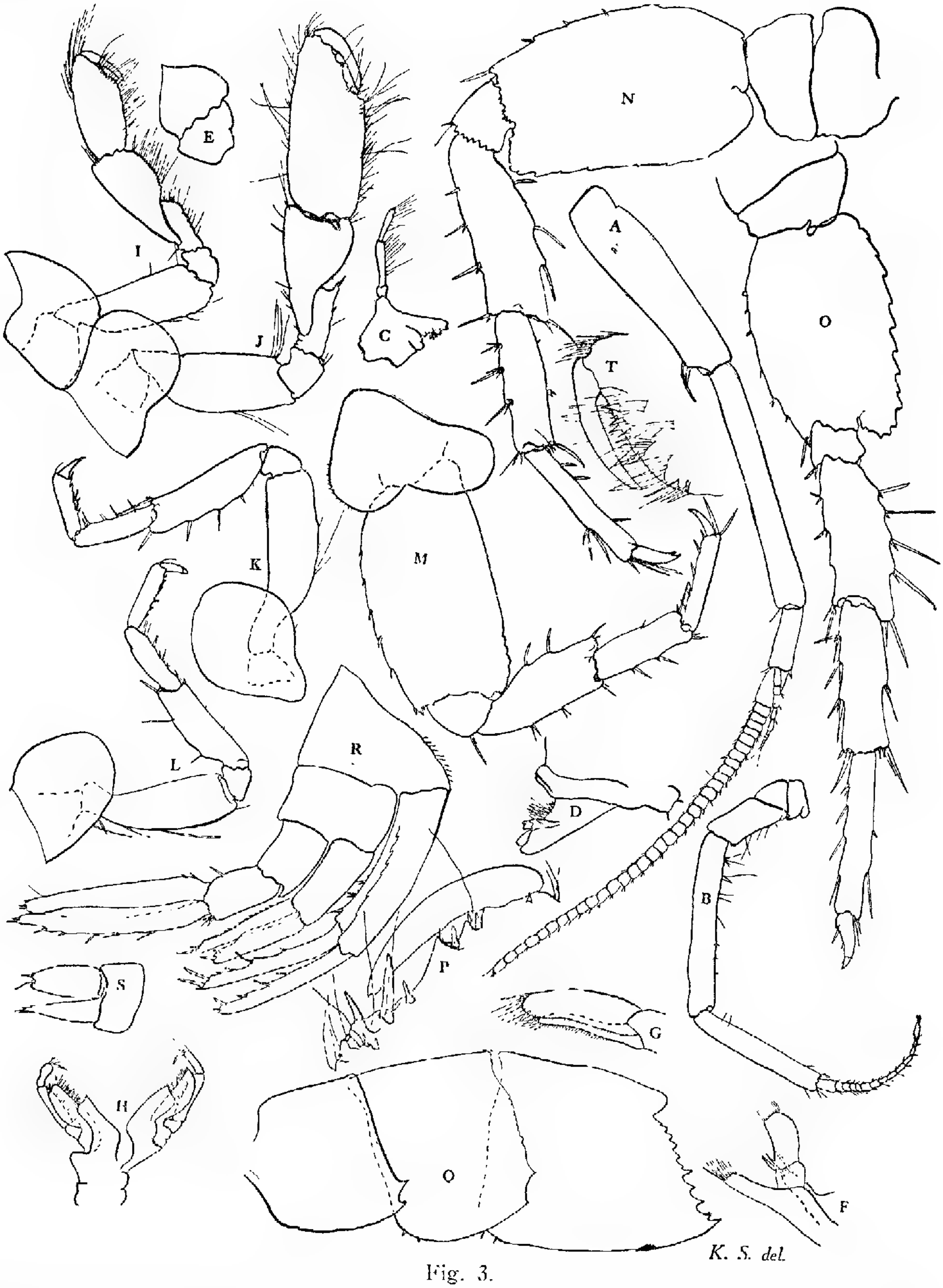


Fig. 3.

*Maera mastersi* (Hasw.), Male—A, antenna 1; B, antenna 2; C, mandible; D, cutting edge, mandible; E, upper lip; F, maxilla 1; G, maxilla 2; H, maxillipeds; I-J, gnathopods 1-2; K-O, peraeopods 1-5; P, palm, gnathopod 2; Q, pleon segments 1-3; R, uropods 1-3; S, telson; T, palm gnathopod 1.

Maxilla 1, outer plate with eight weak spines, inner with three spines, palp with setae on apex only. Maxilla 2 with a light fringe of very short setae on the inner margins of both plates.

Maxilliped with the second joint of the palp not expanded, twice as long as third; appendage sparingly setose.

Gnathopods 1-2, the palmar armature varies somewhat in different specimens, those figured representing the average type.

Peraeopods 1-2, slender and lightly spined, joint four a little expanded along the hinder edge. Peraeopods 3-5, bear the following length ratios: $9\frac{1}{2}$ : 12 : 11,

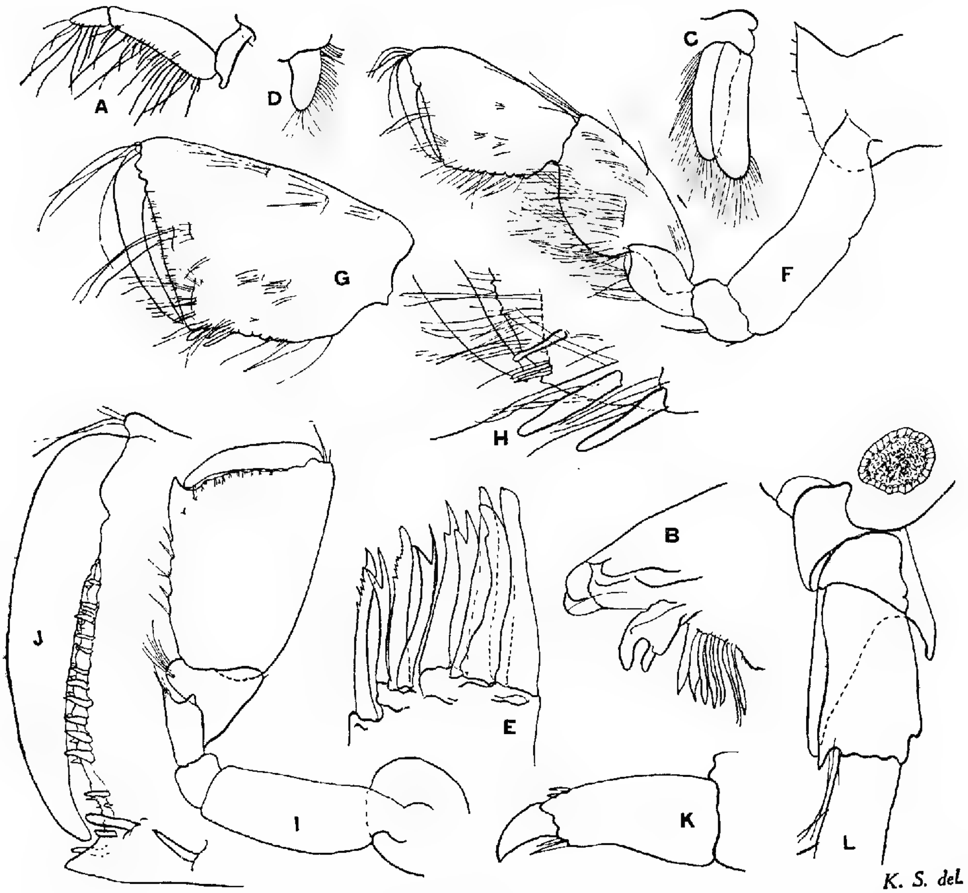


Fig. 4.

*Ceradocus rubromaculatus* (Stimps.), Male—A, palp, mandible; B, cutting edge, right mandible; C, maxilla 2; D, outer plate, maxilla 1; E, tip of inner plate, maxilla 1; F-H, gnathopod 1; I-J, gnathopod 2; K, terminal joints, peraeopod 4; L, joints 1-3 and eye lobe, antenna 2.

and approximate closely in outline to those figured for *Ceradocus rubromaculatus* on pl. xcv of the Challenger reports.

Uropod 1 with rami subequal and subequal to dorsal edge of peduncle; uropod 2 equal to peduncle of uropod 1, rami subequal and subequal to peduncle; uropod 3, rami equal, $2\frac{1}{2}$ times peduncle, shorter than uropod 1. Uropods 1-2 reach only a little beyond the peduncle of uropod 3.

# ABSTRACT OF THE PROCEEDINGS

## Summary

# ABSTRACT OF THE PROCEEDINGS

OF THE

# ROYAL SOCIETY OF SOUTH AUSTRALIA

## (Incorporated).

FOR THE YEAR NOVEMBER 1, 1935, TO OCTOBER 31, 1936.

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ORDINARY MEETING, NOVEMBER 14, 1935.

The President (Dr. C. T. Madigan) and 69 members and visitors present. The Governor (His Excellency Major-Gen. Sir Winston Dugan, K.C.M.G., C.B., D.S.O.) attended and was received by the President.

ELECTION OF FELLOWS.—Herbert George Andrewartha, M.Ag.Sc., Waite Agric. Res. Inst., Glen Osmond; (Mrs.) Hattie Vevers Andrewartha, B.Ag.Sc., M.Sc., 28 Eynesbury Avenue, Mitcham.

PRESENTATION OF THE SIR JOSEPH VERCO MEDAL.—The President announced the presentation of the Verco Medal to Professor T. Harvey Johnston. Sir Douglas Mawson paid a high compliment to the recipient for the variety and excellence of the scientific investigations which he had carried out over a long series of years. Details were given of the many journeys of scientific enquiry extending over every continent and of the highly valuable research conducted by Professor Johnston during two long journeys in Antarctic seas.

His Excellency the Governor, in presenting the Medal, congratulated Professor Johnston on the high honour which the Royal Society had done him. Professor Harvey Johnston appropriately responded.

LECTURES.—Professor J. B. Cleland delivered a lecture on "Native Life in Central Australia," which was elaborated by slides and cinema films depicting native life, shown by Mr. N. B. Tindale.

ORDINARY MEETING, APRIL 9, 1936.

The President (Dr. C. T. Madigan) and 21 members present.

NOMINATIONS AS FELLOWS.—Albert Ray Southwood, M.D., M.S. (Adelaide), M.R.C.P. (London), 170 North Terrace, Adelaide; Hon. Sir Langdon Bonython, K.C.M.G., Montefiore Hill, Adelaide.

PAPERS.—"Notes on the Geological Sections obtained from several Borings situated on the Plain between Adelaide and Gulf of St. Vincent, Pt. II," by Professor W. Howchin; "Anthropometric Observations on South Australian Aborigines of the Diamantina and Cooper Creek Regions," by F. J. Fenner; "Notes on the Natives of the Southern Portion of Yorke Peninsula, South Australia," by N. B. Tindale; "Some Red Basaltic Soils from Eastern Australia," by Professor J. A. Prescott and J. S. Hosking.

"Note on a Sample of Water containing Sulphuretted Hydrogen."

EXHIBITS.—Mr. H. H. Finlayson exhibited a specimen of a rock mass, possibly a sandstone, some surfaces of which showed a decidedly vitreous character, such as to suggest that the rock had experienced incipient fusion. The substance was found by Mr. D. Bowman, of Tempe Downs Station, on a hill near Illamurta on the southern edge of the James Range in Central Australia. Mr. Bowman had suggested that the mass was a product of meteorite impact, and had asked that it should be brought to the notice of geologists.

ORDINARY MEETING, MAY 14, 1936.

The President (Dr. C. T. Madigan) and 40 members and 4 visitors present.

ELECTION OF FELLOWS.—Albert Ray Southwood, M.D., M.S. (Adelaide), M.R.C.P. (London), 170 North Terrace, Adelaide; Hon. Sir Langdon Bonython, K.C.M.G., Montefiore Hill, Adelaide.

PAPERS.—"Analytical Notes on a Sample of Brown Coal from the Balaklava-Inkerman Deposits," by Dr. W. Ternent Cooke; "The Artracoona Meteorite," by A. W. Kleeman, M.Sc.

ADDRESS.—The President delivered his Centenary Address on "The Past, Present and Future of the Society and its Relation to the Welfare and Progress of the State."

EXHIBITS.—Mr. Mincham (visitor) exhibited a series of miscellaneous insects collected in the dry area around Mount Lyndhurst during the past three months. Dr. J. Davidson commented on the exhibit.

ORDINARY MEETING, JUNE 11, 1936.

The President (Dr. C. T. Madigan), 32 members and 1 visitor present.

NOMINATIONS AS FELLOWS.—Lorna Maud Waterhouse, 35 King Street, Brighton; Albert Edward Platt, M.B., B.S., D.T.M., D.T.H. (Syd.), Dip. Bact. (London), Adelaide Hospital.

PAPERS.—"Remarks on the Nematode, *Gongylonema pulchrum*," by Professor T. Harvey Johnston; "Climate in Relation to Insect Ecology in Australia," by Dr. J. Davidson.

ADDRESSES.—"Centenary Resume of Botanical Progress (other than systematic)," by Professor J. G. Wood; "Centenary Review of Anthropology," by Dr. T. D. Campbell.

ORDINARY MEETING, JULY 9, 1936.

The President (Dr. C. T. Madigan) and 25 members present.

ELECTION AS FELLOWS.—Lorna Maud Waterhouse, 35 King Street, Brighton; Albert Edward Platt, M.B., B.S., D.T.M., D.T.H. (Syd.), Dip. Bact. (London), Adelaide Hospital.

ADDRESSES.—"The Past Work of the Royal Society outside the Domain of Natural Science," by Professor R. W. Chapman; "A Hundred Years of Systematic Botany in South Australia," by Mr. J. M. Black.

ORDINARY MEETING, AUGUST 13, 1936.

The President (Dr. C. T. Madigan), 20 members and 2 visitors present.

NOMINATION AS FELLOW.—Keith Sheard, Hon. Assistant in Zoology, South Australian Museum, 46 Sydenham Road, Norwood.

NOMINATION AS ASSOCIATE.—Reginald Claude Sprigg, Student, Lanor Avenue, Goodwood.

ADDRESS.—"A Hundred Years of Entomology in South Australia," by Dr. J. Davidson.

PAPERS.—"The Climatic Control of the Australian Deserts," by Professor J. A. Prescott; "The Regeneration of the Vegetation of the Koonamore Vegetation Reserve, 1926-36," by Professor J. G. Wood.

ORDINARY MEETING, SEPTEMBER 10, 1936.

Dr. T. D. Campbell in the chair, and 24 members and 2 visitors present.

ELECTION AS FELLOW.—Keith Sheard, Hon. Assistant in Zoology, South Australian Museum, 46 Sydenham Road, Norwood.

Election as Associate.—Reginald Claude Sprigg, Student, Lanor Avenue, Goodwood.

Address.—"A Hundred Years of Zoology in South Australia," by Professor T. Harvey Johnston.

Papers.—"The Botanical Features between Oodnadatta and Ernabella in the Musgrave Ranges," by Professor J. B. Cleland; "Studies in Australian Thysanura, No. 1," by H. Womersley; "South Australian Cainozoic Bryozoa," by L. Stach, communicated by Professor W. Howchin.

Annual Meeting, October 8, 1936.

The President (Dr. C. T. Madigan), 35 members and 2 visitors present.

Annual Report read and adopted.

Financial report read and adopted. Thanks expressed to Treasurer and Hon. Auditors.

Election of Officers.—Mr. H. M. Hale, President; Dr. C. T. Madigan, Dr. J. Davidson, Vice-Presidents; Dr. C. A. E. Fenner, Editor; Mr. H. Womersley, Secretary; Dr. W. Christie, Treasurer; Dr. H. K. Fry and Mr. H. H. Finlayson, Members of Council; Messrs. O. Glastonbury and W. Champion Hackett, Auditors.

Professor T. Harvey Johnston moved, and Sir Douglas Mawson seconded, a vote of thanks to the retiring President.

Address.—"Progress in the Knowledge of the Geology of South Australia (A Centennial Review)," by Sir Douglas Mawson.

Papers.—"Descriptions of three new Species, and one variety of Eucalyptus of the Elder and Horn Expedition, etc.," by Mr. W. F. Blakely, communicated by Mr. J. M. Black; "Additions to the Flora of South Australia, No. 34," by Mr. J. M. Black; "On Mammals from the Lake Eyre Basin, Part III," by Mr. H. H. Finlayson; "On the Ecology of the Black-tipped Locust *(Chortoicetes terminifera)* in South Australia," by Dr. J. Davidson, communicated by Mr. D. C. Swan; "Amphipods from a South Australian Reef," by Mr. K. Sheard.

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## ANNUAL REPORT OF COUNCIL, 1935-36.

Presented at the Annual Meeting on October 9, 1936.

The average attendance of Fellows at the meetings held during the year has been thirty four. At the November meeting His Excellency the Governor, Maj.-Gen. Sir Winston Dugan, K.C.M.G., C.B., D.S.O., graciously attended, and was received by the President. During the meeting His Excellency presented the Sir Joseph Verco Medal to Professor T. Harvey Johnston, on behalf of the Society.

During the year seven special Centenary Addresses, reviewing the work of the Society in the various branches of Science, have been given as the Society's contribution to the Centenary of the State. These addresses were:—Dr. C. T. Madigan ("The Past, Present and Future of the Society"), Dr. J. Davidson ("Entomology"), Professor R. W. Chapman ("Other than Natural Sciences"), Professor J. G. Wood ("Botany, other than Systematic"), Mr. J. M. Black

("Systematic Botany"), Dr. T. D. Campbell ("Anthropology"), Professor T. Harvey Johnston ("Zoology"), Sir Douglas Mawson ("Geology").

Papers have been communicated to the Society as follows:—

| | |
|---|---|
| Anthropology - | Messrs. F. Fenner, N. B. Tindale and Prof. Cleland. |
| Entomology - | Dr. J. Davidson and H. Womersley. |
| Zoology - - | Prof. Harvey Johnston; Messrs. K. Sheard, L. Stach, and H. H. Finlayson. |
| Mineralogy - | Mr. A. W. Kleeman and Dr. W. T. Cooke. |
| Geology - - | Prof. W. Howchin. |
| Soils - - | Prof. J. A. Prescott. |
| Climate - - | Prof. Prescott and Dr. J. Davidson (2). |
| Botany - - | Prof. Cleland, Prof. Wood, and Messrs. J. M. Black and W. F. Blakely. |

Seven Fellows and one Associate have been elected, and one Fellow re-admitted during the year; six Fellows have resigned, and two have been struck off the roll. The Membership is now:—Hon. Fellows, 4; Fellows, 160; Associates, 2. Total, 166.

Dr. C. T. Madigan and Professor J. A. Prescott were elected delegates of the Society to the Auckland meeting of the A.N.Z.A.A.S. During the year Mr. N. B. Tindale was granted leave for his trip to America and Europe, and Mr. H. Womersley consented to act as Secretary in his stead.

The Council are gratified that the Board of Governors of the Public Library, Museum and Art Gallery have been able to provide a modern Epidiascope for the use of the Society at its meetings.

The rearrangement of our library by Mr. Tindale and our Librarian has much improved the amenities of our meeting room, and is duly appreciated.

The Council was pleased to receive during the year a partial restoration of the Government Grant.

In his Centenary Address the President outlined a suggestion for a Science House for the Scientific Bodies of this State, and this resulted in the calling together of a meeting of representatives of all suitable societies. A memorandum, stating the views of the societies has now been presented to the Minister for Education, and a report also made to Dr. Grenfell Price of the State Library Commission.

C. T. Madigan, *President*.

H. Womersley, *Secretary*.

October 8, 1936.

# SIR JOSEPH VERCO MEDAL

## Summary

## THE SIR JOSEPH VERCO MEDAL.

The Council, on August 23, 1928, having resolved to recommend to the Fellows of the Society that a medal should be founded to give honorary distinction for scientific research, and that it should be designated the Sir Joseph Verco

Medal, a motion was submitted to the Society at the evening meeting of October 11, 1928, and a later meeting, held on November 8, 1928, the recommendation of the Council was confirmed on the following terms:—

### REGULATIONS.

XI.—"The medal shall be of bronze, and shall be known as the Sir Joseph Verco Medal, in recognition of the important service that gentleman has rendered to the Royal Society of South Australia. On the obverse side of the medal shall be these words: 'The Sir Joseph Verco Medal of the Royal Society of South Australia.' surrounding the modelled portrait of Sir Joseph Verco, while on the reverse side of the medal there shall be a surrounding wreath of eucalypt, with the words: 'Awarded to.....................................................for Research in Science,' the name of the recipient, and the year of the award. The Council shall select the person to whom it is suggested that the medal shall be awarded, and that name shall be submitted to the Fellows at an Ordinary Meeting to confirm, or otherwise, the selection of the Council, by ballot or show of hands. The medal shall be awarded for distinguished scientific work published by a Member of the Royal Society of South Australia."

### AWARDS.

1929 PROF. WALTER HOWCHIN, F.G.S.
1930 JOHN McC. BLACK, A.L.S.
1931 PROF. SIR DOUGLAS MAWSON, B.E., D.Sc., F.R.S.
1933 PROF. J. BURTON CLELAND, M.D.
1935 PROF. T. HARVEY JOHNSTON, M.A., D..Sc.

# BALANCE SHEETS

## Summary

## ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

### Receipts and Payments for the Year ended September 30, 1936.

**RECEIPTS.**

| | £ s. d. | £ s. d. |
|---|---|---|
| To Balance, October 1, 1935 | | 429 19 10 |
| „ Subscriptions | | 169 11 6 |
| „ Government Grant for Printing | | 151 11 1 |
| „ Use of Room by other Societies | 6 6 0 | |
| „ Sale of Publications | 5 5 11 | |
| | | 11 11 11 |
| „ Interest— | | |
| Savings Bank Account | 8 18 1 | |
| Transferred from Endowment Fund | 162 6 6 | |
| | | 171 4 7 |
| | | £933 18 11 |

**PAYMENTS.**

| | £ s. d. | £ s. d. |
|---|---|---|
| By Transactions— | | |
| Printing | 229 7 6 | |
| Illustrating | 70 1 2 | |
| Publishing | 14 10 9 | |
| | | 313 19 5 |
| „ Librarian | | 39 10 0 |
| „ Library— | | |
| Alterations, Furniture and Fittings | | 43 18 0 |
| „ Sundries— | | |
| Cleaning and Lighting | 7 2 8 | |
| Printing, Postages and Stationery | 19 19 0 | |
| Petties | 8 0 7 | |
| Typing | 4 10 0 | |
| Insurance | 6 13 4 | |
| Bank Fee and Cheque Book | 0 15 0 | |
| Verco Medals | 3 16 0 | |
| | | 50 16 7 |
| „ Research Fund | | 5 0 0 |
| „ Balance, September 30, 1936— | | |
| Savings Bank of S.A. | 445 9 4 | |
| Bank of Australasia | 35 5 7 | |
| | | 480 14 11 |
| | | £933 18 11 |

Audited and found correct. We have certified the Bank Balances at the respective Banks,

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
W. CHAMPION HACKETT } Auditors.

W. CHRISTIE, Hon. Treasurer.

Adelaide, October 7, 1936.

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED).

(a) ENDOWMENT FUND as at September 30, 1936.

(Capital .... ... . . £4,899 1s. 1d.)

| | £ s. d. | £ s. d. | | £ s. d. | £ s. d. |
|---|---|---|---|---|---|
| 1935—October 1. | | | 1936—September 30. | | |
| To Balance— | | | By Revenue Account .. ... .... .... | | 171 4 7 |
| Australian Consolidated Stock . | 4,878 10 0 | | Australian Consolidated Stock .... | 4,878 10 0 | |
| Savings Bank of S.A. .... ... .. | 20 11 1 | | Savings Bank of S.A. ... . . .... | 20 11 1 | |
| | | 4,899 1 1 | | | 4,899 1 1 |
| „ Interest Received .... .... .. . | | 171 4 7 | | | |
| | | £5,070 5 8 | | | £5,070 5 8 |

(b) RESEARCH FUND as at September 30, 1936.

| | £ s. d. | £ s. d. | | £ s. d. | £ s. d. |
|---|---|---|---|---|---|
| 1935—October 1. | | | 1936—September 30. | | |
| To Balance—Savings Bank of S.A. .... ... | 1 0 0 | | By Balance— | | |
| „ General Fund, October 31, 1935 .. .... | 5 0 0 | | Savings Bank of S.A. . .... .... | | 6 0 0 |
| | | 6 0 0 | | | |
| | | £6 0 0 | | | £6 0 0 |

Audited and found correct. We have verified the Government Stocks at the Registries of Inscribed Stock, Adelaide, and the Bank Balances at the Savings Bank of South Australia.

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
W. CHAMPION HACKETT } Auditors.

W. CHRISTIE, Hon. Treasurer.

Adelaide, October 7, 1936.

# ENDOWMENT FUND

## Summary

## THE ENDOWMENT FUND.

1902.—On the motion of the late Samuel Dixon it was resolved that steps be taken for the incorporation of the Society and the establishment of an Endowment and Scientific Research Fund. Vol. xxvi., pp. 327-8.

1903.—The incorporation of the Society was duly effected and announced. Vol. xxvii., pp. 314-5.

1905.—The President (Dr. J. C. Verco) offered to give £1,000 to the Fund on certain conditions. Vol. xxix., p. 339.

1935.—The following are particulars of the contributions received and other sources of revenue in support of the Fund up to date:—

### SUMMARY OF THE ENDOWMENT FUND (30/8/35).

(Capital .... .... £4,900 11s. 1d.)

| | £ | s. | d. | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|---|---|---|
| Donations— | | | | | | | | | |
| 1908, Dr. J. C. Verco .... | 1,000 | 0 | 0 | | | | | | |
| 1908, Thomas Scarfe .... | 1,000 | 0 | 0 | | | | | | |
| 1911, Dr. Verco .... .... | 150 | 0 | 0 | | | | | | |
| 1913, Dr. Verco .... .... | 120 | 0 | 0 | | | | | | |
| Mrs. Ellen Peterswald .... | 100 | 0 | 0 | | | | | | |
| 1934, Prof. Walter Howchin, F.G.S. .... .... .... | 40 | 0 | 0 | | | | | | |
| "Anonymous" .... . . .... | 5 | 5 | 0 | | | | | | |
| Small Sums .... . . .... | 6 | 0 | 0 | | | | | | |
| 1934, J. M. Black, A.L.S. .... | 20 | 0 | 0 | | | | | | |
| | | | | 2,441 | 5 | 0 | | | |
| Bequests— | | | | | | | | | |
| 1917, R. Barr Smith .... | 1,005 | 16 | 8 | | | | | | |
| 1920, Sir Edwin Smith .... | 200 | 0 | 0 | | | | | | |
| 1935, Sir J. C. Verco .... | 322 | 17 | 6 | | | | | | |
| | | | | 1,528 | 14 | 2 | | | |
| Life Members' Subscriptions .... .... | | | | 240 | 15 | 0 | | | |
| | | | | | | | 4,210 | 14 | 2 |
| Total Subscribed Capital . . | | | | | | | £4,210 | 14 | 2 |

Additions from the Current Account have been made at various dates. These have enabled the Society to purchase Government Stocks amounting to (face value) £4,880. Cash in Savings Bank on account of the Endowment Fund amounts to £20 11s. 1d. The total capital of this Fund is, therefore, £4,900 11s. 1d.

### GRANTS MADE IN AID OF SCIENTIFIC RESEARCH.

| | £ | s. | d. |
|---|---|---|---|
| 1916, G. H. Hardy, "Investigations into the Flight of Birds" .... .... | 15 | 0 | 0 |
| 1916, Miss H. A. Rennie, "Biology of *Lobelia gibbosa*" .... .. .... | 2 | 2 | 0 |
| 1921. H. R. Marston, "Possibility of obtaining from Azine precipitate samples of pure Proteolytic Enzymes" .. .... . . .... | 30 | 0 | 0 |
| 1921, Prof. Wood Jones, "Investigations of the Fauna and Flora of Nuyts Archipelago" .... .... .. .... .... .... .... .... .... | 44 | 16 | 7 |
| 1934. H. H. Finlayson, "Mammals of Central Australia" ... .. .... | 10 | 0 | 0 |
| 1934. T. T. Colquhoun, M.Sc., "Regeneration of Vegetation after Bush-fires" | 5 | 0 | 0 |
| 1935. H. H. Finlayson, "Mammals of Central Australia" .... .... .... | 5 | 0 | 0 |

W. CHRISTIE, Hon. Treasurer.

# LIBRARY EXCHANGES

## Summary

# ROYAL SOCIETY LIBRARY.

**List of Governments, Societies and Editors with whom Exchanges of Publications are made.**

## AUSTRALIA.

Australasian Institute of Mining and Metallurgy, Melbourne.
Bureau of Census and Statistics, Canberra.
Council for Scientific and Industrial Research, Melbourne.
Library of Commonwealth Parliament.

## SOUTH AUSTRALIA.

Botanic Garden, Adelaide.
Mines Department, Adelaide.
Public Library, Museum, and Art Gallery of South Australia.
Royal Geographical Society of Australasia (S.A. Branch).
South Australian Institutes Association, Adelaide.
South Australian Museum, Adelaide.
South Australian Naturalist, Adelaide.
South Australian Ornithologist, Adelaide.
South Australian Parliamentary Library.
University of Adelaide.
Waite Agricultural Research Institute, Glen Osmond

## NEW SOUTH WALES.

Australian Museum, Sydney.
Botanic Gardens, Sydney.
Department of Agriculture, Sydney.
Geographical Society of New South Wales, Sydney.
Linnean Society of New South Wales.
Mines Department, Sydney.
Public Library of New South Wales.
Royal Society of New South Wales.
Royal Zoological Society of New South Wales.
School of Public Health and Tropical Medicine, Sydney.
Technological Museum, Sydney.
University of Sydney.

## QUEENSLAND.

Department of Agriculture, Brisbane.
Geological Survey, Brisbane.
Queensland Museum, Brisbane.
Public Library of Queensland, Brisbane.
Royal Society of Queensland, Brisbane.
University of Queensland, Brisbane.

## TASMANIA.

Government Geologist, Mines Department, Hobart.
Public Library of Tasmania, Hobart.
Royal Society of Tasmania, Hobart.
University of Tasmania, Hobart.

## VICTORIA.

Field Naturalists' Club of Victoria, Melbourne.
Government Botanist, National Herbarium, Melbourne.
Mines Department, Melbourne.
National Museum, Melbourne.
Public Library of Victoria, Melbourne.
Royal Society of Victoria, Melbourne.
University of Melbourne.

## WESTERN AUSTRALIA.

Geological Survey Department, Perth.
Public Library of Western Australia, Perth.
Royal Society of Western Australia, Perth.
University of Western Australia, Perth.

## ENGLAND.

British Museum Library, London.
British Museum (Natural History), South Kensington.
Cambridge Philosophical Society.
Cambridge University Library.
Conchological Society of Great Britain and Ireland.
Geological Society of London.
Geologists' Association, London.
Imperial Institute, South Kensington.
Imperial Institute of Entomology, London.
Linnean Society of London.
Liverpool Biological Society.
Manchester Literary and Philosophical Society.
National Physical Laboratory, Teddington.
Rhodes House Library, Oxford.
Rothamsted Experimental Station, Harpenden.
Royal Botanic Gardens, Kew.
Royal Empire Society, London.
Royal Entomological Society of London.
Royal Geographical Society, London.
Royal Microscopical Society, London.
Royal Society, London.
Science Museum, South Kensington.
Zoological Museum, Tring, Herts.
Zoological Society of London.

## SCOTLAND.

Edinburgh Geological Society.
Geological Society of Glasgow.
Royal Society of Edinburgh.

## IRELAND.

Royal Dublin Society.
Royal Irish Academy, Dublin.

## CANADA.

Canadian Geological Survey, Ottawa.
Department of Agriculture, Ottawa.
National Research Council of Canada, Ottawa.
Nova Scotian Institute of Science, Halifax.
Royal Canadian Institute, Toronto.
Royal Society of Canada, Ottawa.
University of British Columbia, Vancouver.

## CEYLON.

Colombo Museum, Colombo.

## FEDERATED MALAY STATES.

Royal Asiatic Society, Malayan Branch, Singapore.

## INDIA.

Government Museum, Madras.
Geological Survey of India, Calcutta.
Royal Asiatic Society, Bombay Branch, Bombay.
Zoological Survey of India, Calcutta.

## NEW ZEALAND.

Auckland Institute and Museum.
Dominion Museum, Wellington.
Royal Society of New Zealand, Wellington.
Otago University Museum, Dunedin.
Philosophical Institute of Canterbury, Christchurch.

## SOUTH AFRICA.

Albany Museum, Grahamstown.
Geological Society of South Africa, Johannesburg.
Royal Society of South Africa, Cape Town.
South African Museum, Cape Town.
South African Association for the Advancement of Science, Johannesburg.

## ARGENTINE REPUBLIC.

Academia Nacional de Ciencias, Cordoba.
Universidad de Buenos Aires.

## AUSTRIA.

Akademie der Wissenschaften, Vienna.
Geologische Bundesanstalt, Vienna.
Naturhistorisches Museum, Vienna.
Zoologisch-Botanische Gesellschaft, Vienna.

## BELGIUM.

Académie Royale de Belgique, Brussels.
Institut Solvay, Brussels.
Musée Royale d'Histoire Naturelle de Belgique, Brussels.
Société Entomologique de Belgique, Ghent.
Société Royale de Botanique de Belgique, Brussels.
Société Royale des Sciences de Liège.
Société Royale Zoologique de Belgique, Brussels.

## BRAZIL.

Instituto de Biologia Vegetal, Rio de Janeiro.
Instituto Oswaldo Cruz, Rio de Janeiro.
Museu Paulista, Sao Paulo.

## CHINA.

Geological Society of China, Nanking.
Geological Survey of China, Peiping.
Institute of Biology, National Library of Peiping.
National Research Institute of Biology, Nanking.
Science Society of China, Nanking.
Shanghai Science Institute, Shanghai.
Sun Yatsen University, Canton.

## CZECHO-SLOVAKIA.

Ceskoslovenska Botanicka Spolecnost, Prague.

## DENMARK.

Conseil Permanent International pour l'Exploration de la Mer.
Dansk Naturhistorisk Forening. Copenhagen.
Kobenhavn Universitets Zoologiske Museum.
K. Danske Videnskabernes Selskab. Copenhagen.

## EGYPT.

Société Royale de Geographie d' Egypte, Cairo.

## ESTHONIA.

Universitas Tartuensis, Tartu (Dorpat).

## FINLAND.

Academia Scientiarum Fennica, Helsinki.
Societas Entomologica Helsingforsiensis.
Societas Scientiarum Fennica, Helsingfors.

## FRANCE.

Muséum National d'Histoire Naturelle, Paris.
Société Bourguignonne d'Histoire Naturelle et de Préhistoire, Toulouse.
Société des Sciences Naturelles de l'Ouest de la France, Nantes.
Société Entomologique de France, Paris.
Société Géologique de France, Paris.
Société Linnéenne de Bordeaux.
Société Linnéenne de Normandie, Caen.

## GERMANY.

Bayerische Akademie der Wissenschaften zu München.
Berliner Gesellschaft für Anthropologie, Ethnologie, und Urgeschichte.
Botanischer Garten und Botanisches Museum, Berlin.
Deutsches Entomologisches Institut, Berlin.
Deutsches Museum für Länderkunde, Leipzig.
Fedde, F.: Repertorium specierum novarum regni vegetabilis, Berlin.
Gesellschaft der Wissenschaften zu Göttingen.

Gesellschaft für Erdkunde zu Berlin.
K. Leopoldinische Deutsche Akademie der Naturforscher, Halle.
Naturforschende Gesellschaft, Freiburg.
Naturforschende und Medezinische Gesellschaft, Rostock.
Oberhessische Gesellschaft für Natur- und Heilkunde, Giessen (Lahn).
Preussische Akademie der Wissenschaften, Berlin.
Senckenbergische Bibliothek, Frankfürt a. M.
Zoologisches Museum, Berlin.
Zoologisches Staatsinstitut und Zoologisches Museum, Hamburg.

## HAWAIIAN ISLANDS.

Bernice Pauahi Bishop Museum, Honolulu.
Hawaiian Entomological Society, Honolulu.

## HOLLAND.

Musée Teyler, Haarlem.
Rijks Herbarium, Leiden.

## HUNGARY.

Hydrological Dept., Hungarian Geological Soc., Budapest.
Musée National Hongrois, Budapest.

## ITALY.

Laboratorio di Entomologia, Bologna.
Laboratorio di Zoologia Agraria, Milan.
Laboratorio di Zoologia Generale e Agraria, Portici.
Società Adriatica oi Scienze Naturali, Trieste.
Società di Scienze Naturali ed Economiche, Palermo.
Società Entomologica Italiana, Genova.
Società Italiana di Scienze Naturali, Milan.
Società Toscana di Scienze Naturali, Pisa.

## JAPAN.

Hiroshima University.
Kyōto Imperial University.
Ohara Institute for Agricultural Research, Kurashiki.
Osaka Imperial University, Osaka.
Taihoku Imperial University.
Tokyo Imperial University.

## LATVIA.

Latvijas Universitat, Riga.

## MEXICO.

Instituto de Biologia, Chapultepec.
Instituto Geológico de Mexico.
Sociedad Cientifica "Antonio Alzate," Mexico.

## NORWAY.

Bergen Museum, Bergen.
Botanisk Museum, Oslo.
Kongelige Norske Videnskabers Selskabs, Trondheim.
Tromso Museum, Tromso.

## PHILIPPINE ISLANDS.

Philippine Journal of Science, Manila.

## POLAND.

Société Botanique de Pologne, Warsaw.
Société Polonaise des Naturalistes "Kopernik," Lwow.

## PORTUGAL

Sociedade Broteriana, Coimbra.

## RUSSIA.

Académie des Sciences, Leningrad.
Comité Géologique de Russie, Leningrad.
Institut des Recherches Biologiques de Perm.
Institute of Plant Industry, Leningrad.
Leningrad University.
Ukrainian Academy of Sciences, Kieff.
Université de L'Asie Centrale, Tachkent.

## SPAIN.

Academia de Ciencias y Artes, Barcelona.
Instituto Nacional de Segunda Ensenanza de Valencia.

## SWEDEN.

Entomologiska Föreningen i Stockholm.
Geologiska Föreningen, Stockholm.
Lund University, Lund.
Stockholm's Hōgskolas Bibliotek, Stockholm.
Regia Societas Scientiarum Upsaliensis, Upsala.

## SWITZERLAND.

Geographisch-Ethnographisch Gesellschaft, Zürich.
Institut National Genevois, Geneva.
Naturforschende Gesellschaft, Basel.
Naturforschende Gesellschaft in Zürich.
Société de Physique et d'Histoire Naturelle de Genève.
Société Neuchâteloise des Sciences Naturelles, Neuchâtel.
Société Vaudoise des Sciences Naturelles, Lausanne.

## UNITED STATES.

Academy of Natural Sciences of Philadelphia.
Academy of Science of St. Louis.
American Academy of Arts and Sciences, Boston.
American Chemical Society, Columbus, O.
American Geographical Society, New York.
American Microscopical Society, Manhattan, Kans.
American Midland Naturalist, Notre Dame University, Ind.
American Museum of Natural History, New York.
American Philosophical Society, Philadelphia.
Arnold Arboretum, Jamaica Plain, Mass.
Biological Survey of the Mount Desert Region, Bar Harbour, Me.

Boston Society of Natural History, Boston, Mass.
California Academy of Sciences, San Francisco.
Californian State Mining Bureau, San Francisco.
California, University of, Berkeley, Cal.
Chicago Academy of Sciences.
Citrus Experiment Station, Riverside, Cal.
Connecticut State Library, Hartford, Conn.
Cornell University, Ithaca, N.Y.
Denison Scientific Association, Granville, O.
Field Museum of Natural History, Chicago, Ill.
Franklin Institute of the State of Pennsylvania, Philad.
Harvard Museum of Comparative Zoology, Cambridge, Mass.
Illinois State Natural History Survey, Urbana, Ill.
Illinois University Library, Urbana, Ill.
Indiana Academy of Science, Indianapolis.
Johns Hopkins University, Baltimore, Md.
Kansas University, Lawrence, Kans.
Marine Biological Laboratory, Wood's Hole, Mass.
Maryland Geological Survey, Baltimore, Md.
Michigan University, Chicago.
Missouri Botanical Garden Library, St. Louis, Mo.
Missouri, University of, Columbia.
National Academy of Science, Washington, D.C.
National Geographic Society, Washington, D.C.
New York Academy of Sciences, New York.
New York Public Library.
New York State Library, Albany, N.Y.
New York Zoological Society, New York.
Ohio State University Library, Columbus, O.
Princeton University, Princeton, N.J.
San Diego Society of Natural History, San Diego, Cal.
Smithsonian Institution and Bureau of Ethnology, Washington.
Stanford University, Stanford, Cal.
United States Department of Agriculture, Washington, D.C.
United States Geological Survey, Washington, D.C.
United States National Museum, Washington, D.C.
Wagner Free Institute of Science, Philadelphia, Pa.
Washington University, St. Louis, Mo.
West Virginia University, Morgantown, W. Va.
Yale University Library, New Haven, Conn.

## URUGUAY.

Museo de Historia Natural, Montevideo.
Sociedad de Biologia, Montevideo.

# LIST OF FELLOWS, MEMBERS, ETC.

## Summary

# LIST OF FELLOWS, MEMBERS, ETC.

AS EXISTING ON NOVEMBER 30, 1936.

**Those marked with an asterisk (*) have contributed papers published in the Society's** Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary. *Note.*—The publications of the Society will not be sent to those whose subscriptions are in arrear.

Date of Election.

HONORARY FELLOWS.

1910. *Bragg, Sir W. H., O.M., K.B.E., M.A., D.C.L., LL.D., D.Sc., F.R.S., Director of the Royal Institution, Albemarle Street, London (Fellow 1886).
1926. *Chapman, F., A.L.S., National Museum, Melbourne.
1898. *Meyrick, E. T., B.A., F.R.S., F.Z.S., Thornhanger, Marlborough, Wilts, England.
1894. *Wilson, J. T., M.D., Ch.M., F.R.S., Professor of Anatomy, Cambridge University, England.
1883. †*Howchin, Professor Walter, F.G.S., "Stonycroft," Goodwood East—**Sir Joseph Verco Medal,** 1929; **Rep.-Governor,** 1901-22; **Council,** 1883-84, 1887-89, 1890-94, 1902-33; **President,** 1894-96; **Vice-President,** 1884-87, 1889-90, 1896-1902; **Editor,** 1883-88, 1893-94, 1895-96, 1901-1933; **Honorary Fellow,** 1934.

FELLOWS.

1926. Abell, L. M., Chapman Camp, British Columbia.
1935. Adam, David Bonar, B.Ag.Sc. (Melb.), Waite Agricultural Research Institute, Glen Osmond.
1925. Adey, W. J., C.M.G., 32 High Street, Burnside, S.A.
1927. *Alderman, A. R., M.Sc., F.G.S., West Terrace, Kensington Gardens, S.A.
1931. Andrew, Rev. J. R., Methodist Mission, Salamo, via Samarai, Papua.
1935. Andrewartha, Herbert George, M.Ag.Sc., Waite Agricultural Research Instiitute, Glen Osmond.
1935. Andrewartha Mrs. Hattie Vevers, B.Ag.Sc., M.Sc., 28 Eynesbury Avenue, Mitcham.
1929. Angel, Frank M., 34 Fullarton Rd., Parkside.
1895. †*Ashby, Edwin, F.L.S., M.B.O.U., Blackwood, S.A.—**Council,** 1900-19; **Vice-President,** 1919-21.
1902. *Baker, W. H., Kingana Avenue, King's Park, S.A.
1933. *Barnes, T. A. B.Sc., 13 Leah Street, Forestville.
1932. Begg, P. R., D.D.Sc., L.D.S., 219 North Terrace, Adelaide.
1928. Best, R. J., M.Sc., A.A.C.I., Waite Agricultural Research Institute, Glen Osmond.
1928. *Best, Mrs. E. W., M.Sc., Claremont, Glen Osmond.
1931. Birch, H. McL., M.R.C.S., M.R.C.P., D.P.M., Mental Hospital, Parkside.
1934. Black, E. C., M.B., B.S., Magill Road, Tranmere.
1907. *Black, J. M., A.L.S., 82 Brougham Place, North Adelaide—**Sir Joseph Verco Medal,** 1930; **Council,** 1927-1931; **President,** 1933-34; **Vice-President,** 1931-33.
1936. Bonython, The Hon. Sir Langdon, K.C.M.G., Montefiore Hill, North Adelaide.
1923. Burdon, Roy S., B.Sc., University of Adelaide.
1921. Burton, R. J., Ward Street, Kalgoorlie, W.A.
1922. *Campbell, T. D., D.D.Sc., Dental Dept., Adelaide Hospital, Frome Road, Adelaide—**Rep.-Governor,** 1932-33; **Council,** 1928-32, 1935; **Vice-President,** 1932-34; **President,** 1934-35.
1907. *Chapman, R. W., C.M.G., M.A., B.C.E., F.R.A.S., Professor of Engineering and Mechanics, University, Adelaide—**Council,** 1914-22.
1931. *Chewings, Chas., Ph.D., F.G.S., "Alverstroke," Claremont Road, Glen Osmond.
1929. Christie, W., M.B., B.S., Education Department, Flinders Street, Adelaide—**Treasurer,** 1933-.
1930. Clarke, G. H., B.Sc., Waite Institute, Adelaide.
1895. *Cleland, John B., M.D., Professor of Pathology, University, Adelaide—**Sir Joseph Verco Medal,** 1933; **Council,** 1921-26, 1932-; **President,** 1927-28; **Vice-President,** 1926-27.
1929. Cleland, W. Paton, M.B., B.S., Dashwood Road, Beaumont.
1930. *Colquhoun, T. T., M.Sc., University, Adelaide.
1907. *Cooke, W. T., D.Sc., A.A.C.I., Lecturer, University of Adelaide.
1929. *Cotton, Bernard C., S.A. Museum, Adelaide.

Date of Election.

1924. de Crespigny, C. T. C., D.S.O., M.D., F.R.C.P., 219 North Terrace, Adelaide.
1929. Davidson, James, D.Sc., Waite Agricultural Research Institute, Glen Osmond—**Council**, 1932-35; **Vice-President**, 1935-.
1928. Davies, J. G., B.Sc., Ph. D., Waite Agricultural Research Institute, Glen Osmond.
1927. *Davies, Prof. E. Harold, Mus.Doc., The University, Adelaide.
1930. Dix, E. V., Glynde Road, Firle.
1915. *Dodd, Alan P., Prickly Pear Laboratory, Sherwood, Brisbane.
1932. Dunstone, H. E., M.B., B.S., J.P., 124 Payneham Road, St. Peters.
1921. Dutton, G. H., B.Sc., 12 Halsbury Avenue, Kingswood.
1931. Dwyer, J. M., M.B., B.S., 25 Port Road, Bowden.
1933. Eardley, Miss C. M., B.Sc., 68 Wattle Street, Fullarton Estate.
1902. *Edquist, A. G., 19 Farrell Street, Glenelg.
1925. *England, H. N., B.Sc., Commonwealth Research Station, Griffith, N.S.W.
1917. *Fenner, Chas. A. E., D.Sc., 42 Alexandra Avenue, Rose Park—**Rep.-Governor**, 1929-31; **Council**, 1925-28; **President**, 1930-31; **Vice-President**, 1928-30; **Secretary**, 1924-25; **Treasurer**, 1932-33; **Editor**, 1934-.
1927. *Finlayson, H. H., The University of Adelaide—**Council**, 1936.
1931. Frewin, O. W., M.B., B.S., 68 Woodville Road.
1923. *Fry, H. K., D.S.O., M.B., B.S., B.Sc., Glen Osmond Road, Parkside—**Council**, 1933-.
1932. *Gibson, E. S. H., B.Sc., 297 Cross Roads, Clarence Gardens.
1935. Glastonbury, James Oliver Garnet, B.A., M.Sc., Dip.-Ed., 4 Mornington Road, Unley.
1919. †Glastonbury, O. A., Adelaide Cement Co., Brookman Buildings, Grenfell Street.
1927. Godfrey, F. K., Robert Street, Payneham, S.A.
1935. †Goldsack, Harold, Coromandel Valley.
1934. Goodhart, W. W., 7 Harrow Road, St. Peters.
1925. †Gosse, J. H., Gilbert House, Gilbert Place, Adelaide.
1880. *Goyder, George, A.M., B.Sc., F.G.S., 232 East Terrace, Adelaide.
1910. *Grant, Kerr, M.Sc., Professor of Physics, University, Adelaide—**Council**, 1912-15.
1933. Gray, James H., M.B., B.S., Orroroo.
1930. Gray James T., Orroroo, S.A.
1933. Greaves, H., Director, Botanic Garden, Adelaide.
1904. Griffith, H., Hove, Brighton.
1934. Gunter, Rev. H. A., Woodside, S.A.
1916. Hackett, W. Champion, 35 Dequetteville Terrace, Kent Town.
1927. *Hackett, C. J., M.D., c/o Bank of Adelaide, London.
1922. *Hale, H. M., The Director, S.A. Museum, Adelaide—**Council**, 1931-34; **Vice-President**, 1934-.
1924. Hawker, Captain C. A. S., M.A., M.H.R., Dillowie, Hallett, South Australia.
1927. Holden, E. W., B.Sc., Dequetteville Terrace, Kent Town, S.A.
1933. Hosking, H. C., B.A., 24 Northcote Terrace, Gilberton.
1930. *Hosking, J. S., B.Sc., Waite Agricultural Research Institute, Glen Osmond.
1924. *Hossfeld, Paul S., M.Sc., Office of Home and Territories, Canberra.
1928. Hurcombe, Miss J. C., 95 Unley Road, New Parkside.
1928. Ifould, Percy, Kurralta, Burnside.
1918. *Ising, Ernest H., c/o Comptroller's Office, S.A. Railways, Adelaide—**Council**, 1934-.
1918. *Jennison, Rev. J. C., Yankalilla, S.A.
1910. *Johnson, E. A., M.D., M.R.C.S., Town Hall, Adelaide.
1934. Johnston, J., A.S.A.S.M., 32 Fisher Street, Norwood.
1921. *Johnston, Professor T. Harvey, M.A., D.Sc., University, Adelaide—**Sir Joseph Verco Medal**, 1935; **Rep.-Governor**, 1927-29; **Council**, 1926-28; **Vice-President**, 1928-31; **President**, 1931-32.
1929. Johnston, W. C., Manager, Government Experimental Farm, Kybybolite, S.A.
1920. *Jones, Professor F. Wood, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc., F.R.S., University, Melbourne—**Rep.-Governor**, 1922-27; **Council**, 1921-25; **President**, 1926-27; **Vice-President**, 1925-26.
1918. Kimber, W. J., 28 Second Avenue, Joslin.
1933. *Kleeman, A. W., M.Sc., 12 Ningana Avenue, Kings Park.
1915. *Laurie, D. F., Agricultural Department, Flinders Street, Adelaide.
1930. Le Messurier, D. H., B.Sc., 133 Mills Terrace, North Adelaide.
1922. Lendon, Guy A., M.D., B.S., M.R.C.P., North Terrace.
1930. Louwyck, Rev, N. H., The Rectory, Yankalilla.
1931. *Ludbrook, Mrs. N. H., M.A., Elimatta St., Reid, F.C.T.
1922. *Madigan, C. T., M.A., B.E., D.Sc., F.G.S., University of Adelaide—**Council**, **1930-33**; **Vice-President**, 1933-35; **President**, 1935 36.
1923. Marshall, J. C., Darroch, Payneham.

Date of Election.

1928. *MAEGRAITH, B. G., M.B., B.S., Magdalen College, Oxford, England.
1930. MAGAREY, MISS K. DE B., B.A., B.Sc., 38 Winchester Street, Malvern.
1932. MANN, E. A., C/o Bank of Adelaide, Adelaide.
1929. MARTIN, F. C., M.A., Technical High School, Thebarton.
1905. *MAWSON, SIR DOUGLAS, D.Sc., B.E., F.R.S., Professor of Geology, University, Adelaide Sir Joseph Verco Medal, 1931; **Rep.-Governor,** 1933-; **President,** 1924-25; **Vice-President,** 1923-24, 1925-26.
1919. MAYO, HELEN M., M.D., 47 Melbourne Street, North Adelaide.
1920. MAYO, HERBERT, LL.B., K.C., 16 Pirie Street, Adelaide.
1934. MCCLOUGHRY, C. L., B.E., A.M.I.E. (Aust.), 271 Melbourne Street, North Adelaide.
1929. MCLAUGHLIN, E., M.B., B.S., M.R.C.P., Adelaide Hospital.
1907. MELROSE, ROBERT T., Mount Pleasant.
1930. MILLER, J. I., 18 Ralston Street, Largs Bay.
1925. †MITCHELL, Professor SIR WILLIAM, K.C.M.G., M.A., D.Sc., The University, Adelaide.
1933. MITCHELL, M. L., B.Sc., Fitzroy Terrace, Prospect.
1924. MORISON, A. J., Deputy Town Clerk, Town Hall, Adelaide.
1930. MORRIS, L. G., Beehive Buildings, King William Street, Adelaide.
1925. †MURRAY, HON. SIR GEORGE, K.C.M.G., B.A., LL.M., Magill, S.A.
1926. *MOUNTFORD, C. P., c/o Engineering Branch, G.P.O., Adelaide.
1930. OCKENDEN, G. P., Public School, Streaky Bay, S.A.
1913. *OSBORN, T. G. B., D.Sc., Professor of Botany, University, Sydney—**Council,** 1915-20, 1922-24; **President,** 1925-26; **Vice-President,** 1924-25, 1926-27.
1929. PAULL, ALEC G., M.A., B.S., 10 Milton Avenue, Fullarton Estate.
1924. PERKINS, PROFESSOR A. J., Marlborough Street, Brighton.
1928. PHIPPS, IVAN F., Ph.D., Waite Agricultural Research Institute, Glen Osmond.
1926. *PIPER, C. S., M.Sc., Waite Agricultural Research Institute, Glen Osmond.
1936. PLATT, ALBERT E., M.B., B.S., D.T.M., D.T.H. (Syd.), Dip. Bact. (London), Adelaide Hospital, Adelaide.
1925. *PRESCOTT, PROFESSOR J. A., D.Sc., A.I.C., Waite Agricultural Research Institute, Glen Osmond—**Council,** 1927-30, 1935-; **Vice-President,** 1930-32; **President,** 1932-33.
1926. PRICE, A. GRENFELL, C.M.G., M.A., Litt.D., F.R.G.S., St. Mark's College, North Adelaide.
1925. RICHARDSON, Professor A. E. V., M.A., D.Sc., "Urrbrae," Glen Osmond, S.A.
1911. *ROACH, B. S., 81 Kent Terrace, Kent Town—**Treasurer,** 1920-32.
1925. ROGERS, L. S., B.D.Sc., 192 North Terrace, Adelaide.
1905. *ROGERS, R. S., M.A., M.D., D.Sc., F.L.S., 52 Hutt Street, Adelaide—**Council,** 1907-14, 1919-21; **President,** 1921-22; **Vice-President,** 1914-19, 1922-24.
1931. RUDD, E. A., 10 Church Street, Highgate.
1934. SHINKFIELD, R. C., Meteorological Bureau, West Terrace, Adelaide.
1933. SCHNEIDER, M., M.B., B.S., 175 North Terrace, Adelaide.
1924. *SEGNIT, RALPH W., M.A., B.Sc., Assistant Government Geologist, Flinders Street, Adelaide—**Secretary,** 1930-35.
1925. *SHEARD, HAROLD, Nuriootpa.
1936. SHEARD, KEITH, S.A. Museum, Adelaide.
1928. SHOWELL, H., 27 Dutton Terrace, Medindie.
1920. SIMPSON, A. A., C.M.G., C.B.E., F.R.G.S., Lockwood Road, Burnside.
1924. SIMPSON, FRED. N., Pirie Street, Adelaide.
1925. †SMITH, T. E. BARR, B.A., 25 Currie Street, Adelaide.
1936 SOUTHWOOD, ALBERT R., M.D., M.S. (Adel.), M.R.C.P. (Lond.), Medical Practitioner, 170 North Terrace, Adelaide.
1935. STRICKLAND, ARTHUR GEOFFREY, M.Ag.Sc. (Melb.), 14 Stirling Street, Tusmore.
1922. SUTTON, J., Fullarton Road, Netherby.
1932. SWAN, D. C., B.Sc., Waite Agricultural Research Institute, Glen Osmond.
1924. SYMONS, IVOR G., Murray Street, Lower Mitcham.
1929. *TAYLOR, JOHN K., B.A., M.Sc., Waite Agricutural Research Institute, Glen Osmond.
1933. TAYLOR, Miss V., 40 Eton Street, Malvern.
1923. *TINDALE, N. B., B.Sc., South Australian Museum, Adelaide—**Secretary,** 1935-36.
1935. TRIGG, FRANK, Government Printing Office, Adelaide.
1894. *TURNER, A. JEFFERIS, M.D., F.E.S., Wickham Terrace, Brisbane, Queensland.
1925. TURNER, DUDLEY C., National Chambers, King William Street, Adelaide.
1933. WALKLEY, A., B.A., B.Sc., Ph.D., 20 Urrbrae Avenue, Myrtle Bank.
1924. WALKER, W. D., M.B., B.S., B.Sc., c/o National Bank, King William Street.
1912. *WARD, L. KEITH, B.A., B.E., D.Sc., Govt. Geologist, Flinders Street, Adelaide—**Council,** 1924-27, 1933-35; **President,** 1928-30; **Vice-President,** 1927-28.
1936. WATERHOUSE, LORNA M., 35 King Street, Brighton.
1930. WHITELAW, A. J., B.Sc., High School, Mount Gambier.

Date of Election.

1931. WILSON, CHAS. E. C., M.B., B.S., "Woodfield," Fisher Street, Fullarton.
1920. *WILTON, Professor J. R., D.Sc., University of Adelaide.
1935. WINKLER, REV. M. T., B.A., 20 Austral Terrace, Malvern.
1930. *WOMERSLEY, M., F.R.E.S., A.L.S., S.A. Museum, Adelaide—**Secretary, 1936-.**
1923. *WOOD, J. G., D.Sc., Ph.D., Professor of Botany, University of Adelaide—**Council, 1935-.**

ASSOCIATE.

1935. *FENNER, FRANK JOHN, 42 Alexandra Avenue, Rose Park.
1936. SPRIGG, REGINALD CLAUDE, Lanor Avenue, Goodwood.

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| 1928-30 | L. KEITH WARD, B.A., B.E., D.Sc., F.G.S.A. |
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| 1931-32 | PROF. T. HARVEY JOHNSTON, M.A., D.Sc. |
| 1932-33 | PROF. J. A. PRESCOTT, D.Sc., A.I.C. |
| 1933-34 | J. M. BLACK, A.L.S. |
| 1934-35 | T. D. CAMPBELL, D.D.Sc., |
| 1935-36 | C. T. MADIGAN, M.A., B.E., D.Sc., F.G.S. |
| 1936- | H. M. HALE |

### SECRETARIES.

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| 1877 | W. C. M. FINNISS. |
| 1877-81 | WALTER RUTT, C.E. |
| 1881-92 | W. L. CLELAND, M.B. |
| 1892-93 | W. C. GRASBY. |
| 1893-94 | W. B. POOLE. |
| 1894-95 | W. L. CLELAND, M.B. / W. B. POOLE. |
| 1895-96 | W. L. CLELAND, M.B. |
| 1896-09 | G. G. MAYO, C.E. |
| 1909-12 | R. H. PULLEINE, M.B., Ch.M. |
| 1912-24 | WALTER RUTT, C.E. |
| 1924-25 | CHAS. FENNER, D.Sc. |
| 1925-30 | R. H. PULLEINE, M.B., Ch.M. |
| 1930-35 | RALPH W. SEGNIT, M.A., B.Sc. |
| 1935-36 | NORMAN B. TINDALE, B.Sc. |
| 1936- | HERBERT WOMERSLEY |

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| 1877 | J. S. LLOYD. |
| 1877-83 | THOMAS H. SMEATON. |
| 1883-92 | WALTER RUTT, C.E. |
| 1892-94 | W. L. CLELAND, M.B. |
| 1894-09 | WALTER RUTT, C.E. |
| 1909-20 | W. B. POOLE. |
| 1920-32 | B. S. ROACH |
| 1932-33 | CHAS. FENNER, D.Sc. |
| 1933 | W. CHRISTIE, M.B., B.S. |

### EDITORS.

| | |
|---|---|
| 1877-83 | PROF. RALPH TATE, F.G.S., F.L.S. |
| 1883-88 | PROF. WALTER HOWCHIN, F.G.S. |
| 1888-93 | PROF. RALPH TATE, F.G.S., F.L.S. |
| 1893-94 | PROF. WALTER HOWCHIN, F.G.S. / PROF. RALPH TATE, F.G.S., F.L.S. |
| 1894-95 | PROF. RALPH TATE, F.G.S., F.L.S. |
| 1895-96 | PROF. WALTER HOWCHIN, F.G.S. |
| 1896-00 | PROF. RALPH TATE, F.G.S., F.L.S. |
| 1901-33 | PROF. WALTER HOWCHIN, F.G.S. |
| 1934- | CHAS. FENNER, D.Sc. |

### REPRESENTATIVE GOVERNORS.

| | |
|---|---|
| 1877-83 | [SIR] CHARLES TODD, C.M.G., F.R.A.S. |
| 1883-87 | H. T. WHITTELL, M.A., M.D., F.R.M.S. |
| 1887-01 | PROF. RALPH TATE, F.G.S., F.L.S. |
| 1901-22 | PROF. WALTER HOWCHIN, F.G.S. |
| 1922-27 | PROF. F. WOOD JONES, M.B., etc. |
| 1927-29 | PROF. T. H. JOHNSTON, M.A., D.Sc. |
| 1929-31 | CHAS. FENNER, D.Sc. |
| 1932-33 | T. D. CAMPBELL, D.D.Sc. |
| 1933- | SIR DOUGLAS MAWSON, D.Sc., F.R.S |

# GENERAL INDEX

## Summary

# GENERAL INDEX.

[Generic and specific names in italics indicate that the forms described are new to science.]

Fig. 1. Fig. 2.

Photo, B. C. Cotton

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1. [illegible] 2. [illegible] 3. [illegible] 4. Ngaltjagintata

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1. Ngalijuru Kappina

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Photograph of the Artracoona Meteorite, South Australia. Two-fifths natural size.

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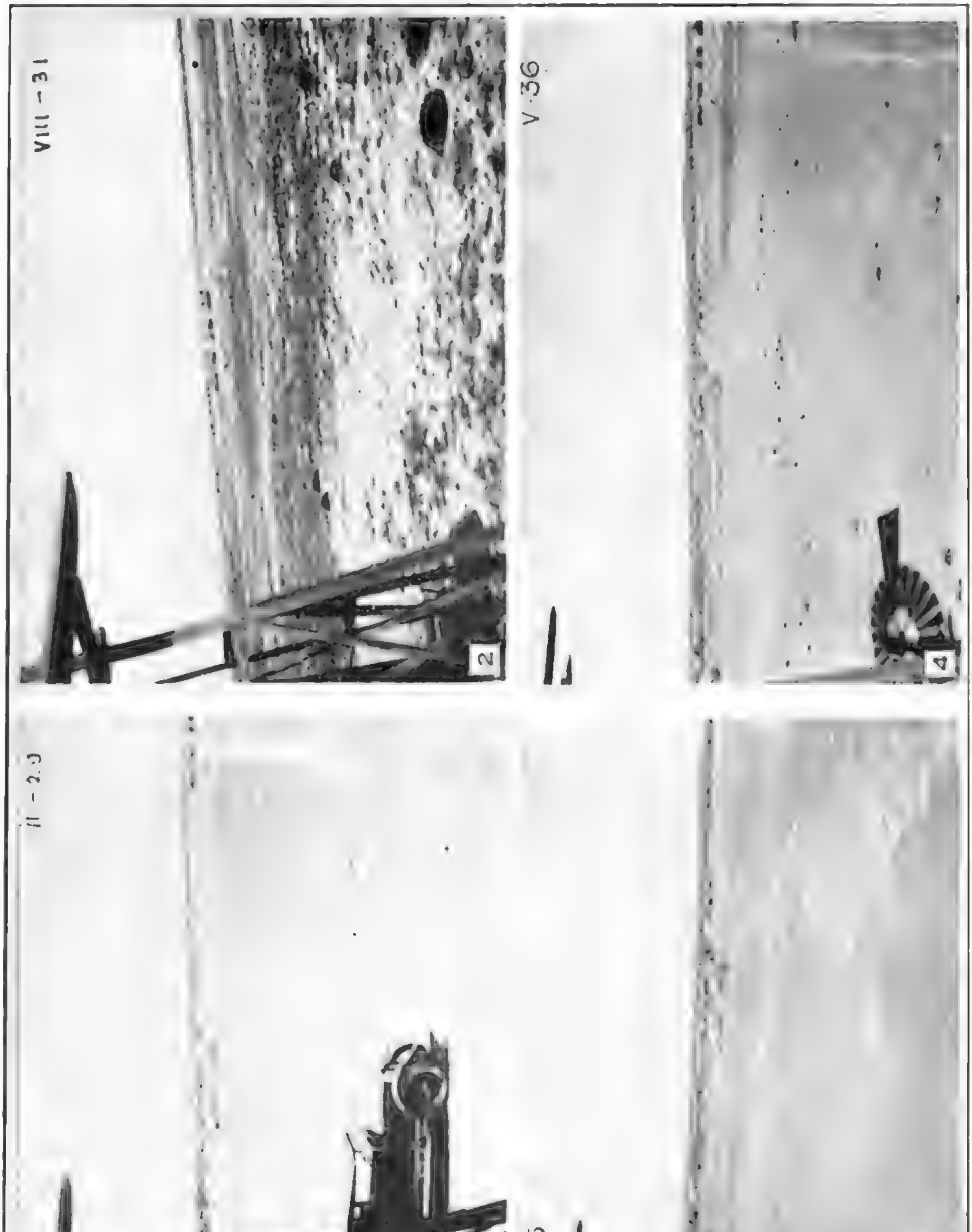


Series of photographs taken from a point at an overstocked bore.

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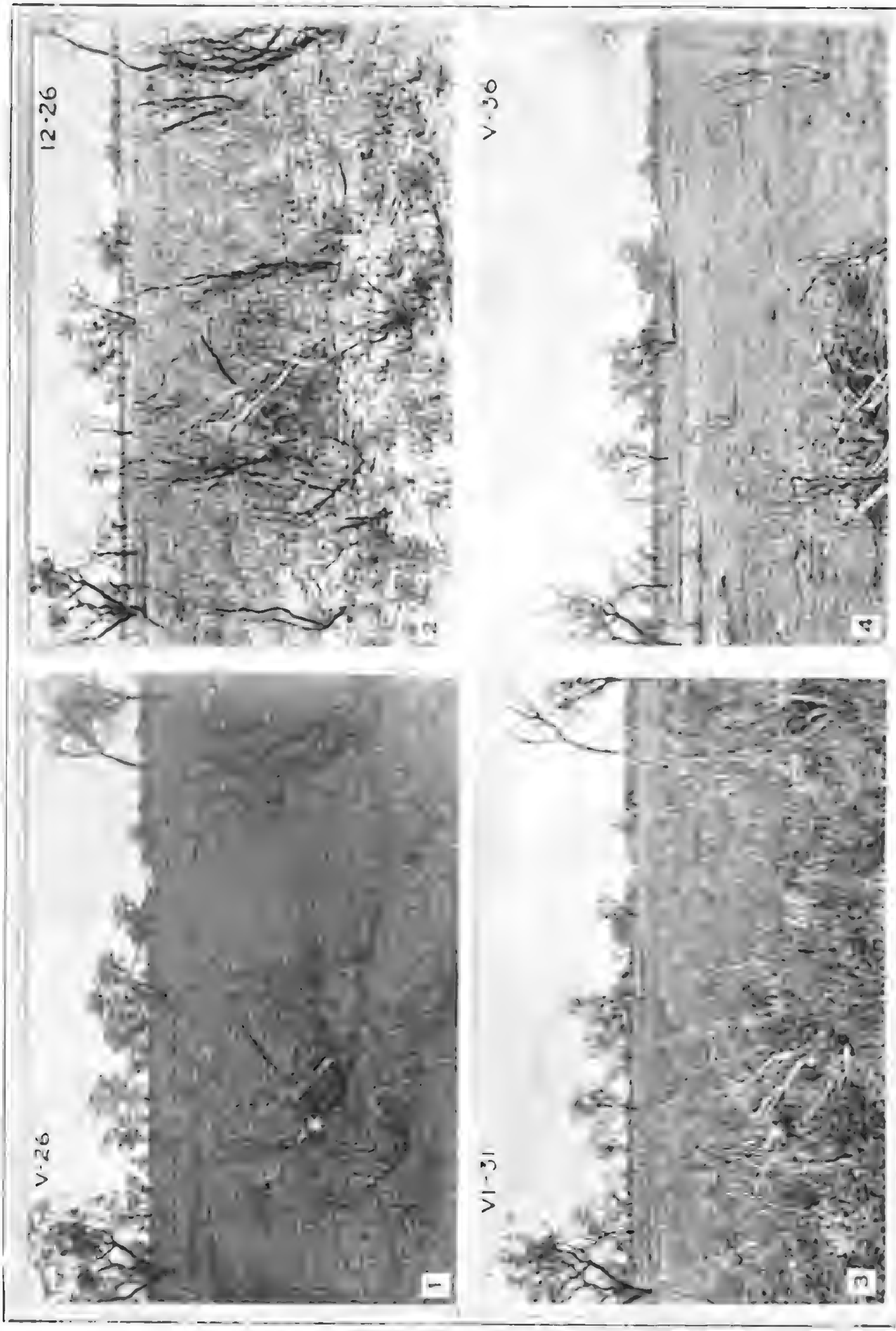


Cycle of vegetation changes on overstocked saltbush community. The bushes have disappeared but the soil is still held by *Bassia*, spp.

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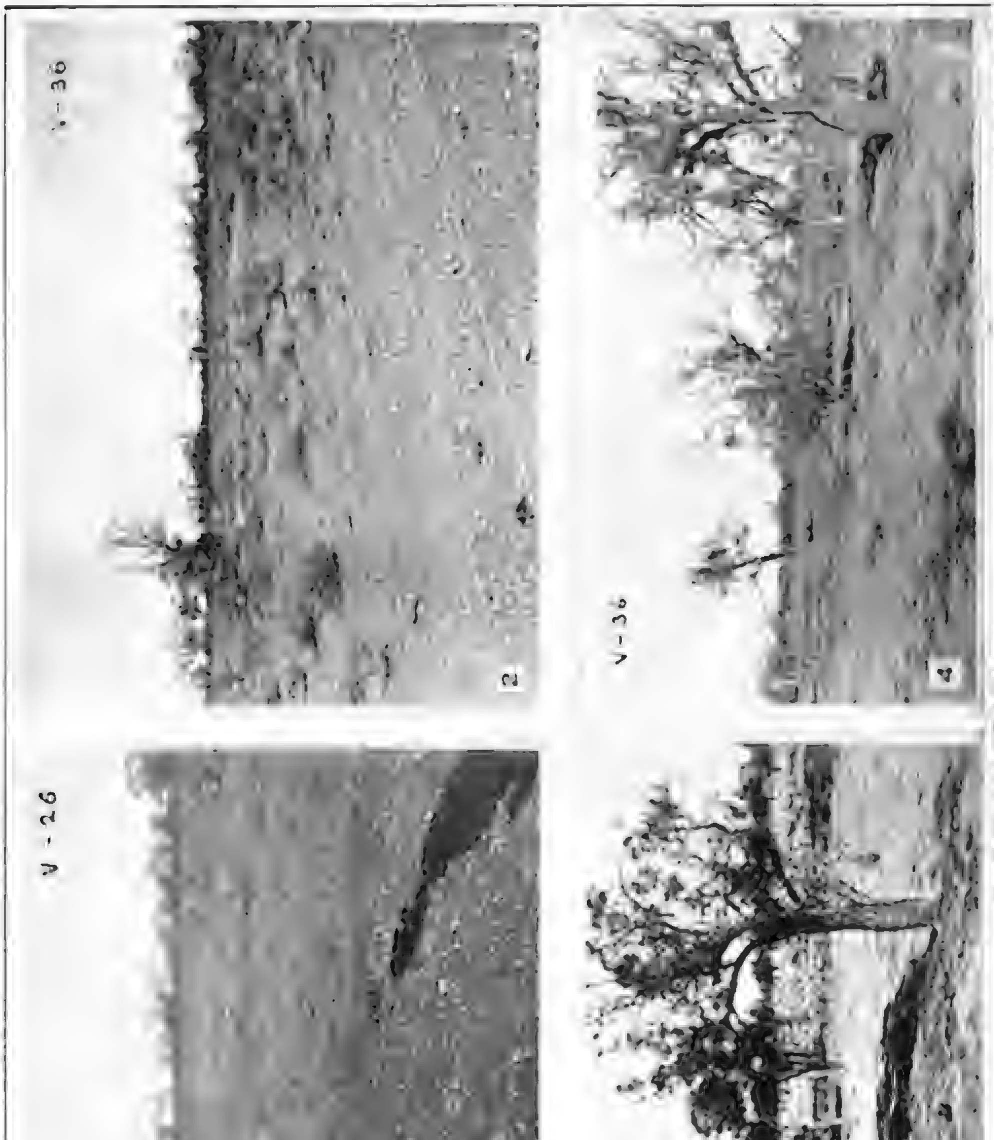


Two areas showing regeneration of saltbush.

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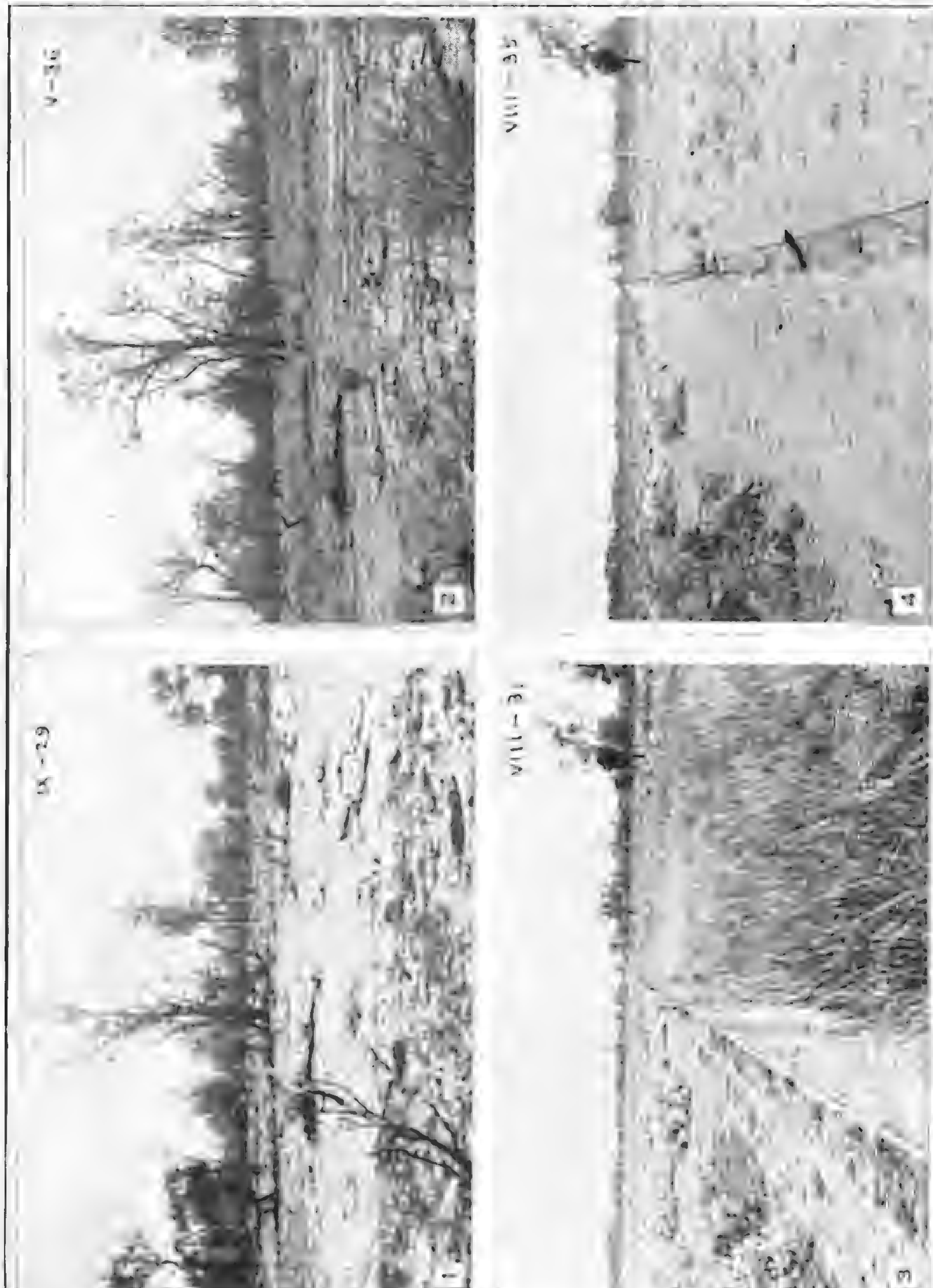


Two areas showing vegetation variations over several years, as set out in context.

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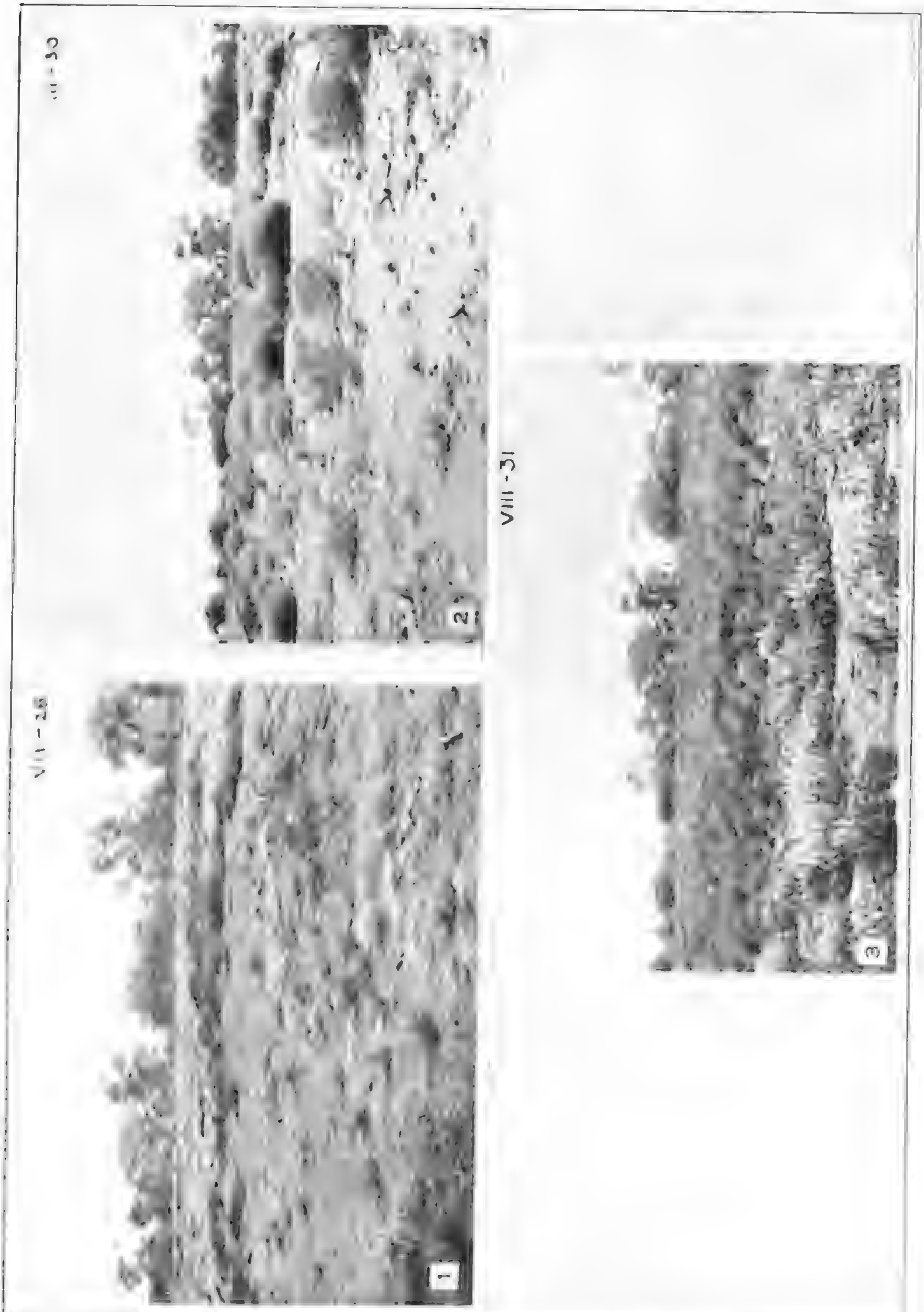


Cycle of vegetation changes on a disturbed sandhill (continued on next plate).

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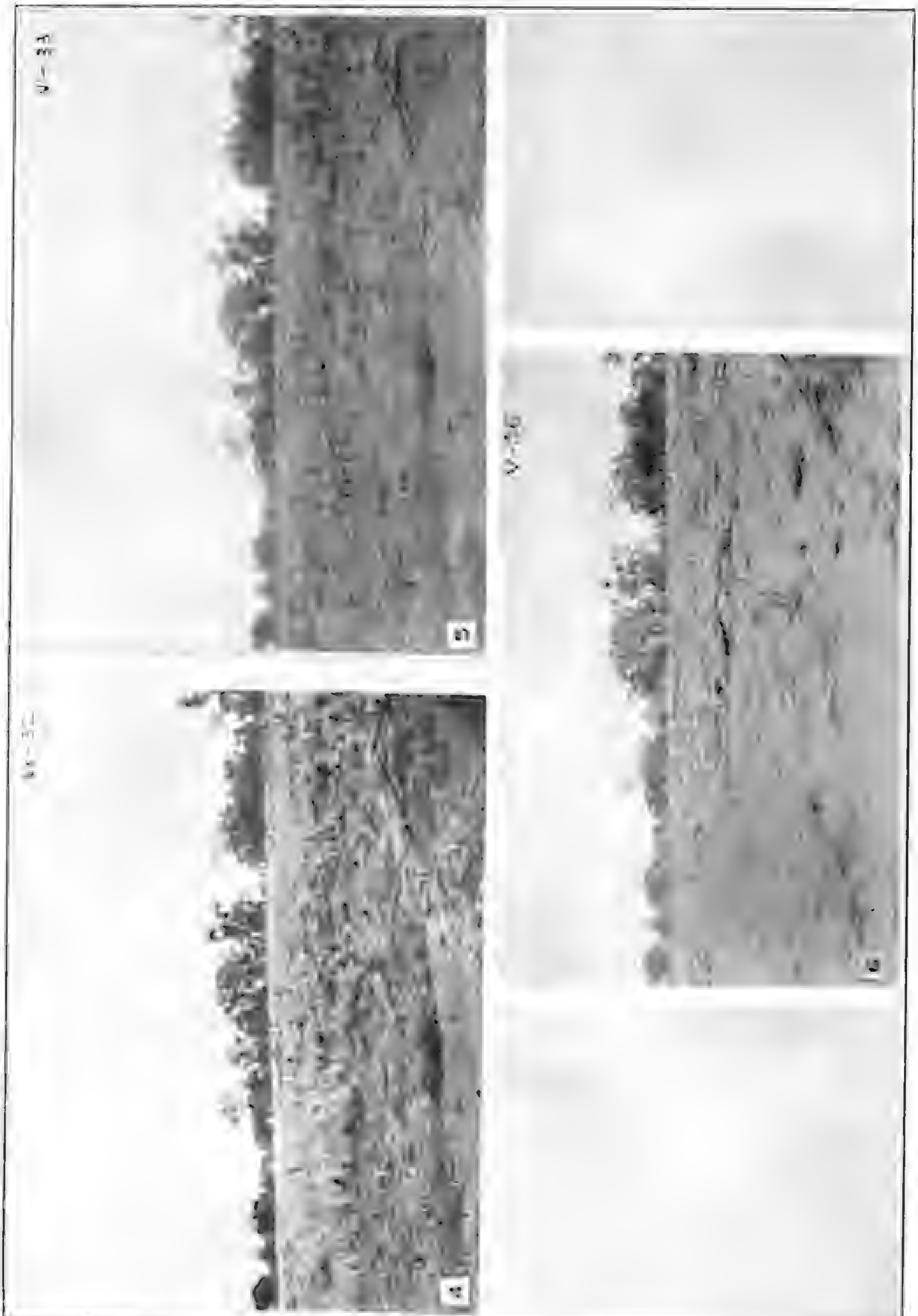

Cycle of vegetation changes on a disturbed sandhill (continued from last plate).

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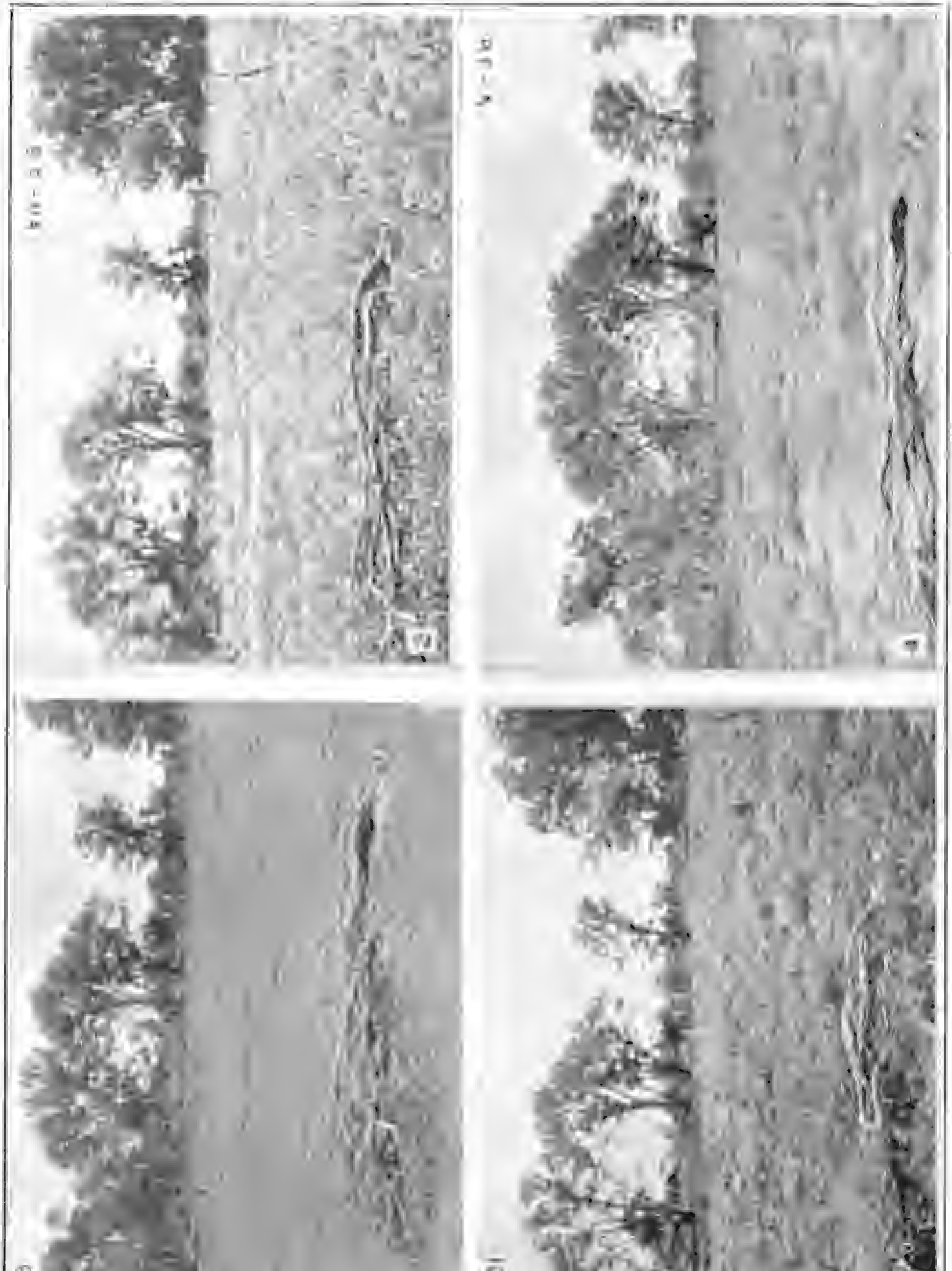

Cycle of vegetation changes on stable sandhill.

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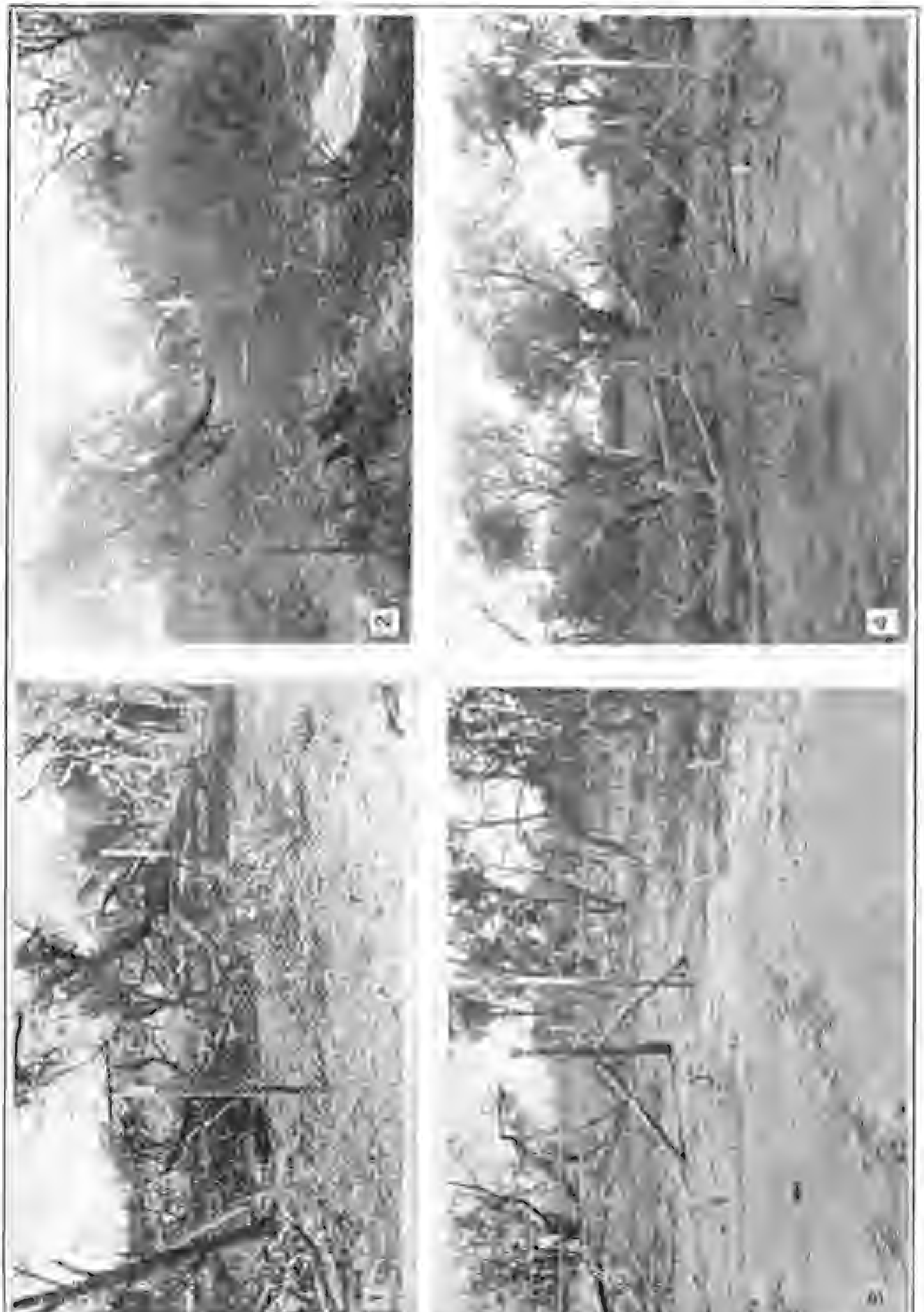

Two areas showing regeneration of trees and shrubs

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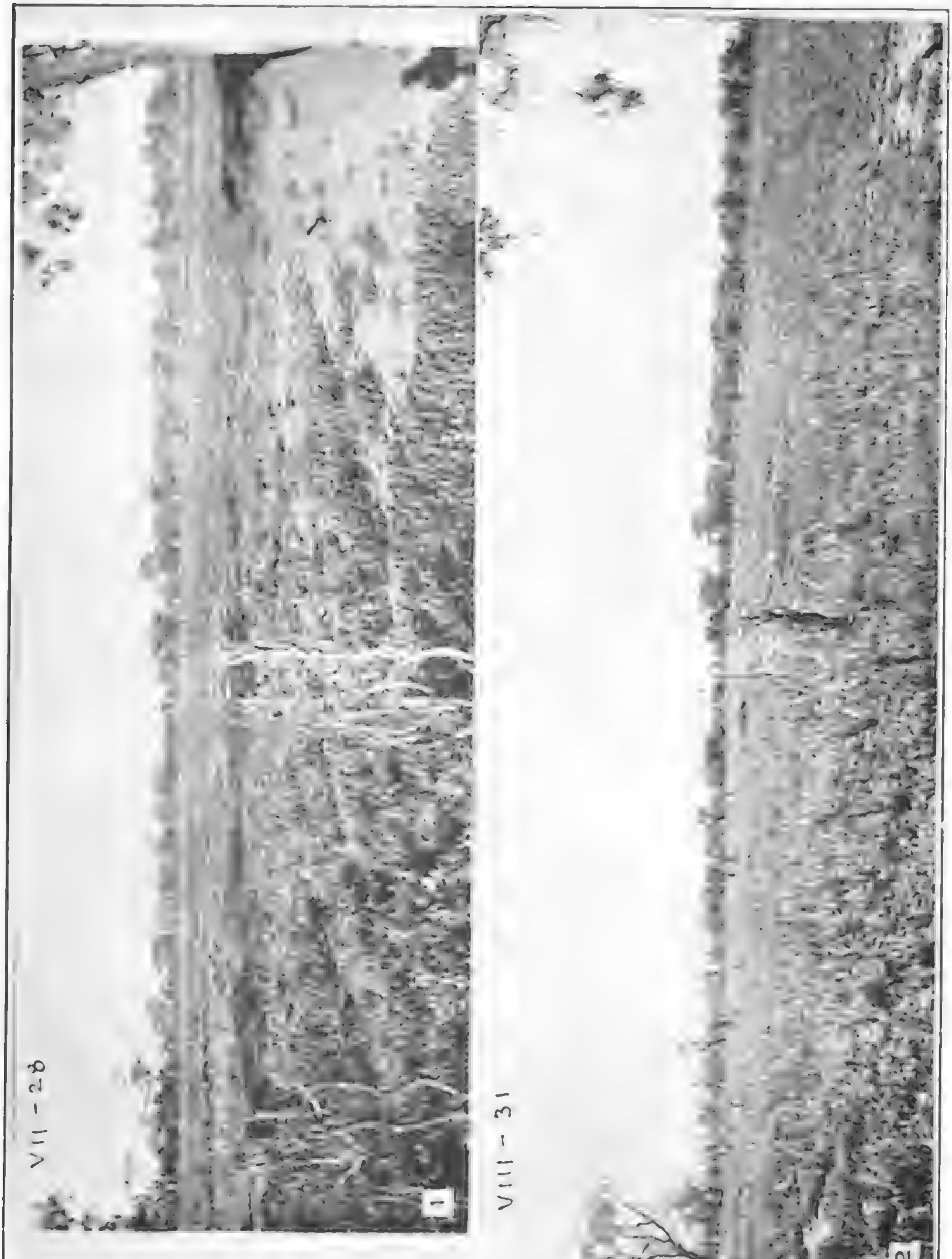


Study of vegetation changes on a flooded area with silty soil (continued on next plate).

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Cycle of vegetation changes on a flooded area with silty soil (cont[illegible] from last plate).

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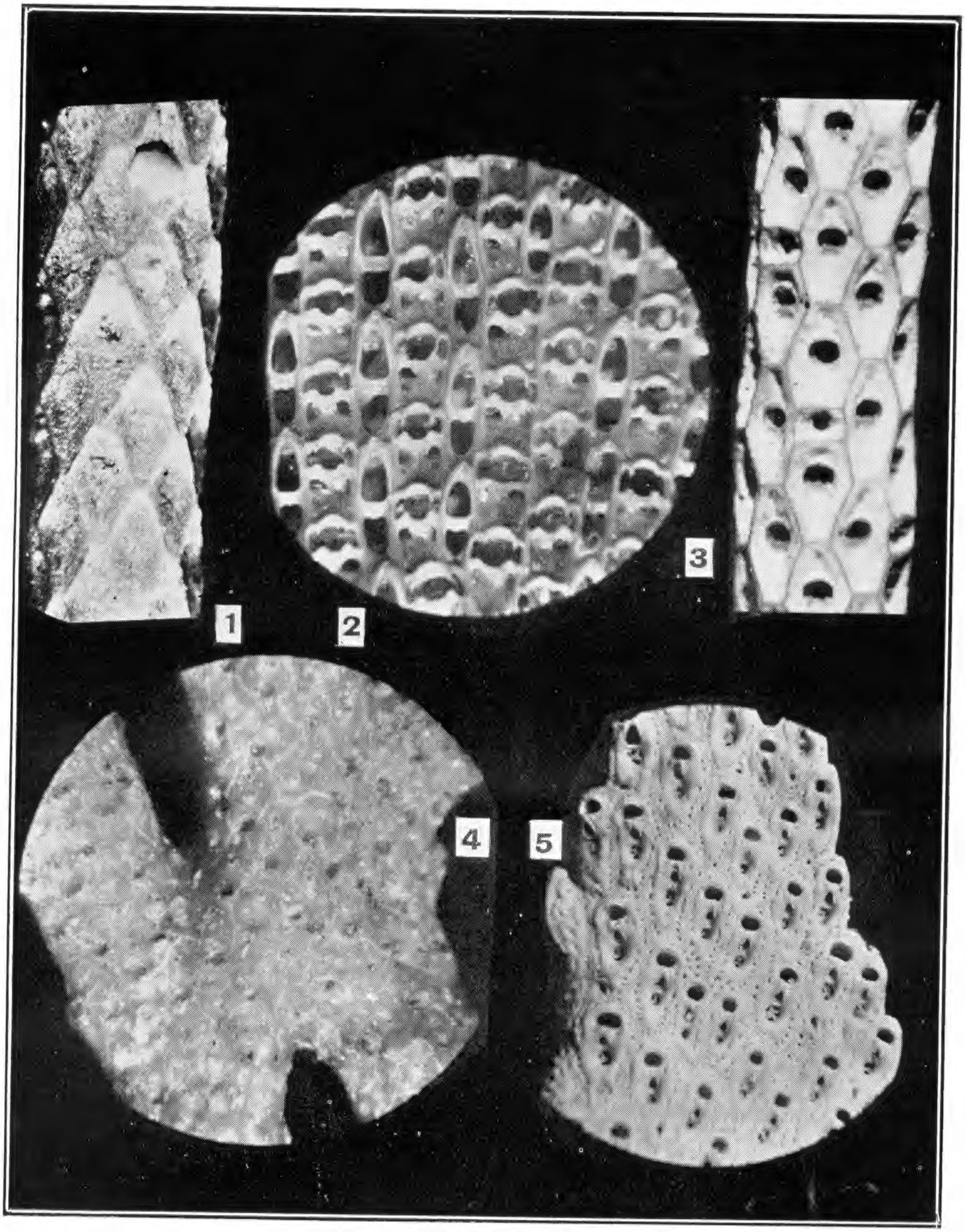



BRYOZOA FROM COWANDILLA BORE, S.A.

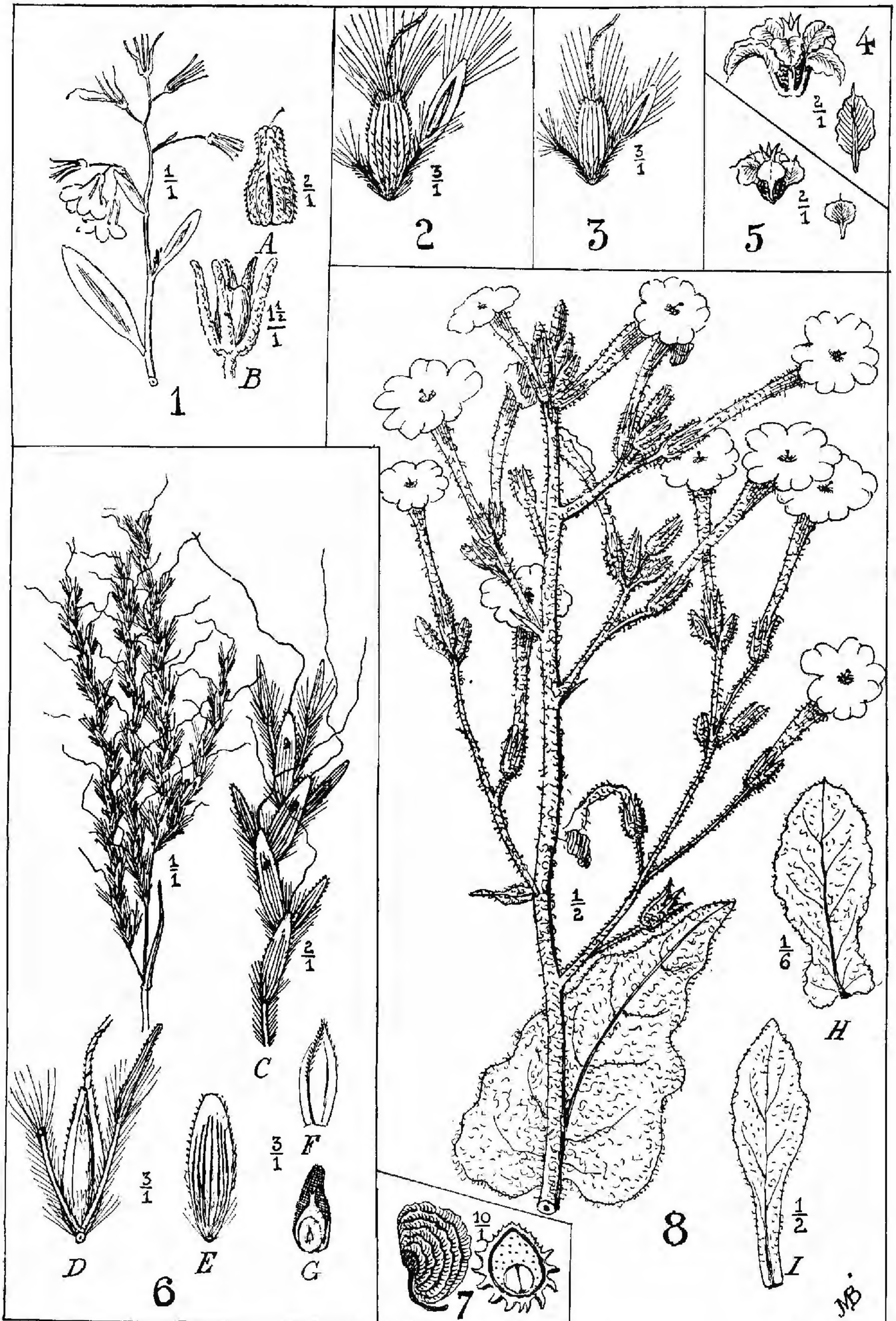
Fig. 1. *Cellaria variabilis* (Busk, 1884). Cowandilla Bore at 520 to 550 feet. Plesiotype, South Aust. Mus. Coll., No. L 7.

Fig. 2 *Thalamoporella howchini*, sp. nov. Cowandilla Bore at 485 to 507 feet. Holotype, Q South Aust Mus. Coll., No. L 2.

Fig. 3. *Cellaria australis* Macgillivray, 1880. Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 6.

Fig. 4. *Sertella porcellana* (Macgillivray, 1869). Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 9.

Fig. 5. *Adeonellopsis australis* Macgillivray, 1886. Cowandilla Bore at 485 to 507 feet. Plesiotype, South Aust. Mus. Coll., No. L 10.




1. *Halgania glabra*. 2. *Dichanthium sericeum*. 3. *Dichanthium humilius*. 4. *Amaranthus grandiflorus*. 5. *Amaranthus Mitchellii*. 6. *Bothriochloa decipiens*. 7. *Arthrocnemum halocnemoides* var. *pterygospermum*. 8. *Nicotiana Gossei*.

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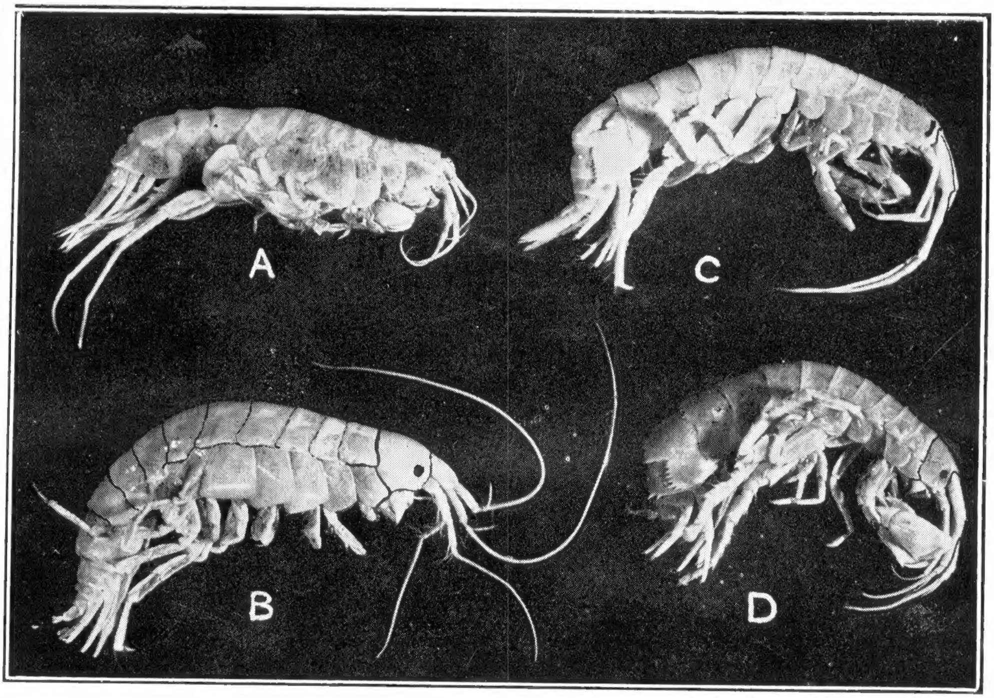


—Photo by Bernard C. Cotton.

A *Oediceroides pirloti*, n. sp.
B *Grubia variatus*, n. sp.
C *Macra mastersi*
D *Ceradocus rubromaculatus*

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# CONTENTS